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The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Future Supplies	463
The Trend of Business	463
British Ironfounders' Association : Annual Dinner in London	464
Random Shots	464
Alloying of Malleable Iron	465
The Trend of Research on Foundry Matters	467
Iron and Steel Production	467
X-Ray Examination of Castings	468
Notes from the Branches	468
Open-Hearth Practices in a Steel Castings Plant	469
Modern Views of Cast Iron	471
Some Notes on the Properties of Chilled Metallic Shot and Grit Used in Sand-Blasting	474
Book Reviews	476
A Discussion on Cupola Practice	477
Economy in Alloying Elements	478
Federation of Iron and Steel Merchants	478
The Week's News in Brief	480
Trade Talk	480
Personal	480
Obituary	480
New Company	480
Patent Specifications Accepted	480
Company Reports	480
Forthcoming Events	480
Raw Material Markets	482
Publication Received	482
Contracts Open	482

Future Supplies

For many years it has been stated that there has been a dearth of foundry apprentices. In order to obtain a clear appreciation of the problem we recently sent out a questionnaire on the subject. From an examination of the returns it is clear that the heavy ironfounders and jobbing shops are reasonably well supplied, as the percentages range from 66 down to 25. It is obvious that, owing to the complexity of the industry, it cannot be considered as a whole, and the light-repetition foundries have in many cases entirely dispensed with apprentices. Again, in the attached foundries such as the electrical-engineering shops, the attractions of the other departments tend to rob the foundries. The one outstanding exception is the case where the foundry has a detached site, and here the percentage is 26. The motor-vehicle foundries are a little difficult to assess, because of the small proportion of skilled men employed in the foundry services, associated in some cases with the provision of a private technical school where a general training is given covering foundry activities. The textile foundries are reasonably well supplied with youths, and between 20 and 25 per cent. can be considered normal. In the steelfoundry the returns vary from 8 to 30 per cent., with an average of 18. This figure is, for steel, on the low side, unless a marked growth of intensive mechanisation can preserve an economic balance. Both the non-ferrous and malleable trades complain of a shortage of suitable entrants, and a dearth of moulders is also more pronounced at the present time than in any other section. Apparently about 15 per cent. of the foundries employ no apprentices or trainees, and this applies mainly to the light repetition concerns. By including those firms which employ no apprentices at all, we find that in general the industry is employing 18 per cent., but, omitting these cases, nearly 21 per cent. Taking the average working life of a moulder to be 30 years, and that of an apprentice 4 years, then the proportion of apprentices to moulders should be about 13 per cent. Thus, as far as we can see, on theoretical statistical grounds, the future supply is being adequately taken care of, but there are many desiderata such as geographical distribution, and youths leaving the industry during or after the apprenticeship period; thus the 18 per cent. is, we should imagine, by no means too large a margin. Deflection into executive positions should be well taken care of in our figure of 30 years' service for the skilled operative; moreover, some of the returns record the percentage against both skilled and semi-skilled moulders. Finally, we wish to extend our sincere thanks to those who have so kindly furnished us with details which have enabled us to assess the present position.

The Trend of Business

The trend of business at the moment is somewhat difficult to estimate and subject to certain rather puzzling factors. With regard to steel, following a not unanticipated rise in the price of hematite iron, it was announced that acid steel products would not be increased next year. This and earlier announcements regarding stabilised steel prices have been received very well by users, although Mr. Arthur Chamberlain, prominently connected with the tube trade, said that prices were bound to fall and hence that stabilisation is a mistake. The setback in the States is undoubted, although, since it is attributed to a "strike of capital," it seems to have a political rather than an economic cause. Export trade on a virtual world basis, covering fifty countries, appears to have declined about 1 per cent. in value in the third quarter of the year. In this country activity in the heavy trades is well maintained, in spite of a slight slackening in the motor and radio industries, and there is no doubt that many orders will be released as soon as the present pressure shows any sign of slackening. Taking everything into consideration, political as well as economic and industrial, we think that the industry may face the immediate future with confidence and that there is in this country no sign of any business recession.

In the meantime, the movement towards control of the trade cycle grows steadily, and pressure is being brought to bear on municipalities and local authorities generally to make their great public works extensions when the cycle is tending downwards, thus helping to prevent a crest on the upward portion as well as a trough on the downward portion. The authorities in their turn, knowing that money is most easily obtained when times are good, are declaring that it is a matter for the Government to decide. A uniform policy is, of course, desirable for the whole country, but the contact between Whitehall and the local areas is so close that there should be no difficulty in arranging one.

C

British Ironfounders' Association

ANNUAL DINNER IN LONDON

The annual dinner of the British Ironfounders' Association and its kindred organisations, the British Bath Manufacturers' Association and the National Light Castings Ironfounders' Federation, was held last Thursday at the Langham Hotel, Portland Place, London, W. Mr. W. R. Blair, the chief executive officer, was in the chair. He was supported at the high table by Mr. James Allan, Mr. Stanley Benham, Mr. A. Brooks, Mr. H. Cheetham, Mr. C. H. W. Davey, Mr. Percy Donald, Mr. C. W. Edwards, Capt. H. J. Kennard, Col. W. Macfarlane, Mr. W. W. Mathieson, Mr. W. Stanley Palmer, Sir W. R. Dudley Pryke, Bt., Mr. J. W. Rains, Mr. Wm. Rennie, Mr. Geo. Scotland, Mr. W. P. Sproull, Mr. J. B. F. Watson and Mr. T. R. C. Whyman.

After the loyal toast had been honoured, Mr. A. Brooks (President of the British Federation of Builders Merchants' Association) proposed "The B.I.A. and Kindred Organisations," and eulogised the judicial impartiality invariably shown by Mr. Blair during the conduct of business between his Federation and the light-castings industry. Mr. Wm. Rennie (chairman of Federated Foundries, Limited) responded, and made a strong plea for strengthening the bath organisation. He was satisfied that the B.I.A. was accomplishing good work, whilst the National Light-Castings Ironfounders' Federation carried out their task of negotiating with the appropriate trade unions.

The toast of the guests was proposed by Mr. A. P. Harrop (of Yates, Haywood & Company), and was replied to by Mr. W. Stanley Palmer (of the Ironmongers' Federated Association). Mr. Palmer drew attention to the increasing costs now being experienced by the retailer, through recent social legislation, space requirements for the display of goods, and the high rateable value of centrally-situated premises.

Mr. Andrew Shanks again delighted the company with a selection of operatic songs.

The following is a list of those present at the banquet:—

G. L. Anderson; R. Archibald; R. Arrowsmith; J. B. Ballantine; A. C. Beal; H. Bell; J. G. Bennett; F. Bowen; W. J. Boyd; W. D. Boyle; J. B. Brand; J. B. Briggs; James Brown; Norman Bruce; Cyril L. Burn; John Cameron; John Cameron, Jr.; D. F. Campbell; J. M. Campbell; A. H. Carmichael; R. Carrick; Frank Chatwin; O. B. Clausen; A. G. Colley; S. F. Corby; L. H. Crump; Percy Cummings; W. Daniels; H. W. Davis; C. W. Dawson; H. Dawson; J. N. Deas; R. Dickson; Bruce Donald; Percy Donald; Thos. Dudley; B. C. Dyson; E. Edwards; T. L. Elliott; W. J. Farrant; V. C. Faulkner; A. R. Fraser; John A. Frost; P. L. Garrett; F. T. D. Hall; A. P. Harrop; H. B. Harrop; J. Harrower; Reg. H. Hellyer; W. Hodkin; J. Hogg; E. W. Holloway; A. Hutchison, Sr.; A. Hutchison, Jr.; Jas. Jackson; J. B. Jackson; J. M. Jackson; T. Bowyer Jackson; — Jenkins; Victor Jobson; Sam. B. Johnson; Ernest Jones; J. H. Jones; W. D. Joslin; H. Kear; W. T. Kitching; Capt. H. F. Langley; H. J. Lathe.

Col. W. Macfarlane; F. F. McFadzean; — Mann; J. S. Mathieson; W. D. Mathieson; H. Mason; F. C. Matthews; T. Milroy; Walter W. Mitchell; Wm. T. Mitchell; A. J. Monks; G. Muirie; J. L. Muntus; S. Neve; Col. H. W. O'Brien; John Oswald; J. G. Petrie; C. E. Prosser; J. H. Reynolds; R. L. Rogerson; A. O. Russell; C. L. Scott; Geo. Scotland; Andrew F. Shanks; John Sharp; D. Sharpe; G. Sheffield; H. V. Shelton; J. Simpson; J. D. Sloan; Harry Smith; Sam Smith; S. B. Smith; W. H. Smith (B.F.P.M.A.); W. H. Smith (B.I.A.); J. G. Sneddon; J. L. Sturrock; H. Taylor; W. Todd; A. Wareham; W. H. Watkins; R. Weddell; Normal Welch; R. G. Wharam; E. J. Whitson; T. R. C. Whyman; G. C. Wilson; W. T. Wren; Wm. Wright; A. Young; T. G. Young; K. Zimmermann.

THE GATHERING AT THE ANNUAL DINNER OF THE BRITISH IRONFOUNDERS' ASSOCIATION IN LONDON.

The B.C.R.I.A., "Marksman" reads, is proposing to determine the "capacity," amongst other things, of enamels. Now if they would determine the capacity of the enameller himself instead of the enamel, that would be a research really worth while, and of tremendous value at such times as annual conferences. To have a notice "Good for 8 pints. Tested and approved by the B.C.R.I.A." affixed to one's membership badge would have advantages too obvious to need elaboration. Too often the opacity of the capacity question leads to trouble.

"MARKSMAN."

Random Shots

This is apparently a year of centenaries, two of the most important being, first, a few months ago, that of the P. & O. Steamship Company, and now that of Thomas Firth & John Brown, Limited. For the occasion the latter have issued a beautifully conceived book which recounts the history and progress of the two firms from their earliest beginnings, through their amalgamation, and up to this year, their centenary. The illustrations are majestic, and suggest the force and vigour both behind the enterprise and the type of work they illustrate. The letterpress reads like a romance, and there is, indeed, a wealth of romance in the history and success of almost all the well-known industrial names of Sheffield. In this respect the names of Firth and Brown do not lag behind, for in both cases the firm rose from very small beginnings to world-wide fame within the life-time of the actual founder. In 1863 it appears that the Lords of the Admiralty visited the works, and at a dinner given in their honour by Sir John Brown, speeches were made which would sound equally to the point to-day. The House of Commons, in improving the means of aggression and defence, had done its best to provide for the peace of the world. The first thing they had to do was to maintain the peace and security of the people of England. How could they do that but by keeping themselves on a perfect equality with all the nations of the world? So whilst Messrs. Armstrongs were busy making a 150 pounder to bash in the face of the Fearful Foe, John Brown hastened to increase the thickness of armour plates from 4½ in. to 12 in. in order to resist the attack of such a gun, lest the Fearful Foe should have made any for himself! What a life! In the school yard, the little boy endeavours to strike fear into the bosom of his enemy with the threat, "I'll set my big brother after you," and the big bully retorts with, "Yah, I don't care; I've got nails in my boots and he hasn't!" So the underlying principles of aggression and defence are apparently the same, whether it be in the school-yard, the 19th century or even the 20th century!

(*Continued at foot of previous column.*)

Alloying of Malleable Iron

By W. F. CHUBB, B.Sc.

(*Concluded from page 458.*)

Influence of Molybdenum

Probably the first reference to this subject is that of E. K. Smith and H. C. Aufderhaar ("Iron Age," 1929, Vol. 124, p. 1,507), who reported upon the effects of adding 0.66, 1.77 and 3.10 per cent. of molybdenum to a grey cast iron base. Their researches showed in a qualitative way that molybdenum tended to retain the combined form of carbon, irons containing the highest percentage of molybdenum thereby approaching the condition of white iron. Pearlite structure, when obtained, showed a refinement due to a general inhibition of grain growth, the latter being considered due to the presence of molybdenum in solid solution form.

In order of date, the second contribution is that of F. L. Coonan ("Heat Treating and Forging," 1929, Vol. 15, p. 1,561), who reported more fully as to irons containing a maximum of 1 per cent. molybdenum. These irons were subjected to annealing treatments for 140 hours at 840 deg. C., but as this included the time of cooling, and because, moreover, rates of cooling were not specified, the time consumed at the annealing temperature must be regarded as indefinite. The basic iron used was a white cast

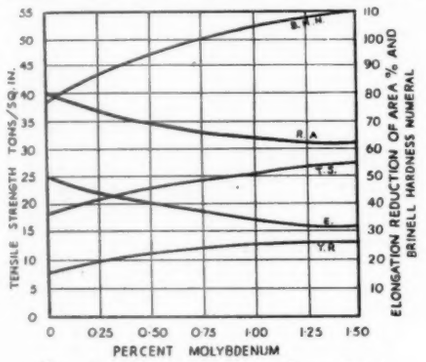

FIG. 1.—MOLYBDENUM IN PURE IRON.

iron of more or less usual composition, and the results revealed a decided increase in both yield point and tensile strength, accompanied by ductility which reached a maximum value with 0.5 per cent. of molybdenum before decreasing with further increases in molybdenum content. In specimens which retained pearlite after annealing, Coonan concluded that molybdenum retarded the dissociation of carbide into temper carbon, a conclusion which was justified by the micrographic evidence obtained.

Prior to the work of Prof. W. H. Jennings, jun., and E. L. Henderson ("Metals and Alloys," 1931, Vol. 2, pp. 223-225), the most complete study of the effects of molybdenum on malleable iron was that of Musatti and Calbiani ("La Metallurgia Italiana," 1930, Vol. 23, p. 649). These authors obtained important improvements in the physical properties through additions of molybdenum.

In the research of Henderson and Jennings, just mentioned, molybdenum additions of from 0 to 4.96 per cent. were covered, the irons being melted in a plumbago crucible by means of a 35 kw. induction furnace. Compositions were adjusted to requirements by additions of high-carbon ferro-molybdenum, 46 per cent. ferro-silicon, and powdered graphite, the melts being cast into sand moulds at a measured temperature of 1,350 deg. C. As this research is considered to be of considerable importance in relation to some original experiments to be described subsequently, the analyses of the irons so made have been reproduced in Table I.

Using gas carbon as the packing material, samples of each composition were annealed at 930 deg. C. for periods of 74 and 100 and 257 hours, being cooled to 450 deg. C. before final removal from the furnace. Microscopic examination was employed to follow the decomposition of cementite. The second stage of graphitisation at 705 deg. C was also studied by a similar procedure, cooling from 930 deg. C. to this temperature being undertaken at a controlled rate of 18.5 deg. C. per hour. Table II shows the collected results.

TABLE I.—*Compositions used by Henderson and Jennings.*

Melt No.	Mo.	C.	Si.	Mn.	S.	P.
S-1-1	0.92	2.79	0.78	0.20	0.031	0.148
	0.92	2.78	0.78	0.20	0.035	0.149
S-12-1	0.93	2.63	0.76	0.18	—	0.149
	0.93	2.70	0.77	0.20	—	0.150
S-6-2	1.84	2.51	0.79	0.19	0.036	0.151
	1.86	2.52	0.82	0.21	0.038	0.151
S-11-2	1.85	2.62	0.86	0.17	—	0.150
	1.86	2.63	0.86	0.20	—	0.151
S-7-3	3.17	2.63	0.66	0.18	0.038	0.149
	2.98	2.63	0.63	0.19	0.036	0.151
S-13-4	4.09	2.55	0.65	0.22	0.034	0.149
	4.11	2.61	0.65	0.19	0.036	0.149
S-14-5	4.95	2.58	0.61	0.21	0.033	0.150
	4.96	2.63	0.62	0.19	0.032	0.151

Alloys containing 1 to 4 per cent. of molybdenum were thus successfully graphitised, but the 5 per cent. alloy, which was originally very hard and tough in the "as-cast" condition, failed to break down into graphite after a heat-treatment lasting more than 10 days. The lengthy annealing treatment required by such an alloy would not be an economic proposition, and, indeed, the results show that molybdenum additions of more than 1 per cent. would not be advantageous from a commercial standpoint.

Jennings and Henderson also examined the influence of alloy additions from purely theoretical grounds by applying the general free energy equation for determining the effects of selected elements on the rates of graphitisation of white cast irons. On this basis they predicted a de-

TABLE II.

Alloy No.	Mo. Per cent.	Time for complete graphitisation, hrs.	
		At 930 deg. C.	At 705 deg. C.
Orindary M.I. ..	0	60 –65	100–105
S-1-1	1	75 –80	120–125
S-12-1	1	75 –80	120–125
S-6-2	2	90–100	160–165
S-11-2	2	90–100	160–165
S-7-3	3	150–155	195–200
S-13-4	4	200–205	245–250
S-14-5	5	Incomplete in 255	Incomplete in 250

crease in the rate of graphitisation by molybdenum, a prediction amply confirmed by their experimental work. Their conclusions may therefore be summarised as follow:—

(1) In both the primary and secondary stages the rates of graphitisation are inversely proportional to molybdenum content over the ranges examined.

(2) Molybdenum conveys a positive refinement of grain structure.

(3) Qualitative observations point to progressive increases in tensile strength, hardness and toughness with increasing molybdenum contents.

The results of some original work must here be included. In studying the influence of molybdenum on malleable irons, it is fundamental to consider the effects of its addition to pure iron. These influences are illustrated in Fig. 1, in which the increases in tensile strength, yield point and hardness which result from progressive additions of molybdenum are seen to be accompanied by a lowering of ductility as measured by percentage elongation and reduction of area.

During extensions of this research, it was revealed that similar effects are also obtained in fully annealed malleable irons alloyed with molybdenum. In addition to these influences upon static physical properties, it has been established that molybdenum greatly increases wear resistance, while it conveys also increases in toughness and in strength at elevated temperatures. These influences are, indeed, common to all ferrous alloys containing molybdenum. Solid solution malleable iron is most readily obtained when molybdenum up to 0.35 per cent. is added to the base iron without change in the standard annealing cycle. This addition results in a final structure which is identical with that of unalloyed blackheart malleable iron, and consists of a single-phase matrix of molybdenum dissolved in ferrite. Additions of molybdenum above the limit mentioned may also be made with advantages to mechanical and other properties, but it is found that in these instances certain modifications either to composition or to annealing treatment are essential in order to yield desirable structures. Thus, when molybdenum between 0.35 and 0.75 per cent. is added to white

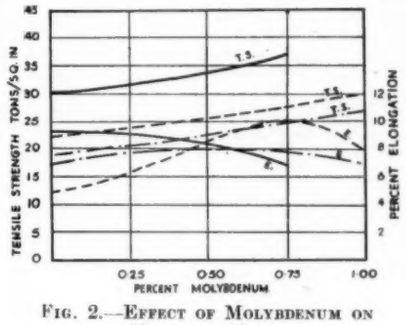

FIG. 2.—EFFECT OF MOLYBDENUM ON MALLEABLE IRON.

Dot and dash lines—High carbon; annealing 140 hrs. at 850 deg. C.
Broken lines—Medium carbon; annealing 100 hrs. at 950 deg. C.
Full lines—Low carbon; annealing 120 hrs. at 900 deg. C.

irons of normal total-carbon content, it is essential either to raise the silicon content or to increase the time of annealing, in order to provide a single-phase matrix in the resulting malleable iron, but realising the mode of occurrence of molybdenum, the reason for these changes will be self-evident. The resulting solid solution types of molybdenum-bearing malleable irons are then characterised by modest improvements in tensile strength and in Brinell hardness, accompanied by a slight gain in ductility. The greatest benefit, however, is to be found in the marked increase in resistance to wear which results from additions of molybdenum.

In Fig. 2 are incorporated the results which normally are to be expected from increasing amounts of molybdenum in malleable iron. It will be observed that at a certain concentration of molybdenum the elongation begins to fall off, thus indicating that the annealing cycle has resulted in retention of pearlite. The metal then no longer consists of a single-phase matrix, but contains also undecomposed carbide in the form of pearlite, having as its effect the loss of ductility noted.

This retention of pearlite may be employed, however, to advantage, for if material in this condition be heat-treated and quenched, marked

changes in properties will result. Thus, it has been observed that in this manner the tensile strength can be increased to over 44 tons per sq. in., while retaining a moderately high ductility of up to 10 per cent. In fact, this treatment, applied to white cast irons containing about 1 per cent. of molybdenum, will provide properties comparable with those of steel castings.

Physical Properties

In discussing the physical properties of molybdenum malleable iron, it is again essential to

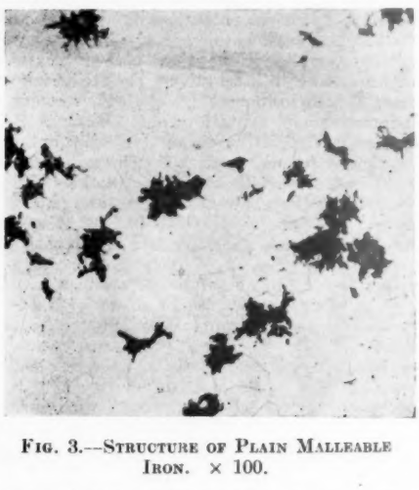

FIG. 3.—STRUCTURE OF PLAIN MALLEABLE IRON. × 100.

bear in mind the method of manufacture. These materials must therefore be considered from this standpoint.

(1) *Air Furnace.*—In the case of fully annealed malleable iron produced by the air furnace, the following alloys may be compared by way of example:—

	Plain. Per cent.	Alloyed. Per cent.
C (after annealing) ..	2.28	1.98
Si	0.97	0.99
Mn	2.23	0.19
S	0.063	0.048
P	0.092	0.092
Mo	Nil	0.43

FIG. 4.—STRUCTURE OF ALLOYED MALLEABLE IRON (0.43 PER CENT. MO). × 100.

The mechanical properties of these materials are as follow:—

	Plain.	Alloyed.
Tensile strength, tons per sq. in.	21.96	24.96
Yield point, tons per sq. in.	15.36	15.67
Elongation in 2 in., per cent.	17.5	20.0
Brinell hardness	116	143

The structures are illustrated in Figs. 3 and 4 respectively, each at a magnification of 100 diameters. Both structures consist of ferrite solid solution with interspersed graphite nodules, but the somewhat similar grain size of the iron containing molybdenum may be noted, the difference being, however, sufficient to account for the superiority of the alloyed iron.

(2) *Air-Furnace Malleable Iron.*—In the fully-annealed short-cycle malleable irons, the following irons are representative:—

	Plain. Per cent.	Alloyed. Per cent.
T.C	2.25	1.90
Si	0.90	1.60
Mn	0.35	0.60
S	0.06	0.06
P	0.10	0.10
Mo	Nil	0.14

Of these irons, the unalloyed material was subjected to a 65-hr. cycle of annealing, and the alloyed iron to a 30-hr. cycle. The physical properties obtained were:—

	Plain.	Alloyed.
Tensile strength, tons per sq. in.	24.55	27.68
Yield point, tons per sq. in.	15.63	16.52
Elongation in 2 in., per cent.	19.0	17.0
Brinell hardness	126	149

(3) *Cupola Iron.*—To a base iron containing:—T.C, 3.06; Si, 0.63; Mn, 0.80; S, 0.010, and P, 0.074 per cent. were added progressively increasing amounts of molybdenum up to approximately 1 per cent. The physical properties as regards tensile strength and elongation have been detailed below.

Molybdenum. Per cent.	Tensile strength. Tons per sq. in.	Elongation. Per cent. in 2 in.
Nil	22.32	5.4
0.17	23.26	6.2
0.32	25.32	6.6
0.46	25.40	9.0
0.67	26.74	9.9
0.84	29.82	10.0
1.01	30.13	8.5

The general conclusion to be drawn from these results is that tensility increase progressively with molybdenum content, but that ductility reaches an optimum value at a certain molybdenum concentration.

(4) *Quick-Anneal Heat-Treated White Iron.*—Three examples of short-cycle heat-treated white irons of the following compositions have been examined:—

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.
T.C	2.15	2.03	1.98
Mn	0.60	0.60	0.44
Si	1.94	1.94	1.92
Mo	Nil	0.41	0.78

For heat-treatment, all three materials were soaked at 940 deg. C. for 4 hrs., cooled in the furnace to 760 deg. C. and quenched in oil. For drawing, the two molybdenum-bearing irons were treated to 730 deg. C., No. 2 alloy being maintained at this temperature for 3 hrs. and No. 3 alloy for 1 hr.; the unalloyed iron was tempered at 680 deg. C. for 2 hrs. The tensile properties detailed below are of considerable interest, and should be examined in conjunction with the corresponding photomicrographs, Figs. 5, 6 and 7.

Physical Properties.

	No. 1.	No. 2.	No. 3.
Tensile strength, tons per sq. in.	34.39	41.25	47.77
Yield point, tons per sq. in.	26.07	33.66	39.46
Elongation, per cent. in 2 in.	4.5	6.5	5.1
Yield ratio, per cent.	75.8	81.6	82.6
Brinell hardness ..	194	217	255
Photomicrograph ..	Fig. 5	Fig. 6	Fig. 7

Although it has not been customary to do so with this type of material, yield ratios representing the relationships between yield points to tensile strengths on a percentage basis have been included in the above summary, and these figures serve to emphasise the beneficial results of molybdenum additions combined with heat-treatment. The microstructures add confirmation to these results, for No. 2 alloy containing 0.41 per cent. of molybdenum is of finer and more dispersed structure than that of the unalloyed iron, while the structure of No. 3 iron of 0.78 per cent. molybdenum content can clearly be identified with the iron of highest tensile strength and hardness.

Foundry Advantages

For the production of malleable iron, whether by the blackheart or whiteheart processes, the

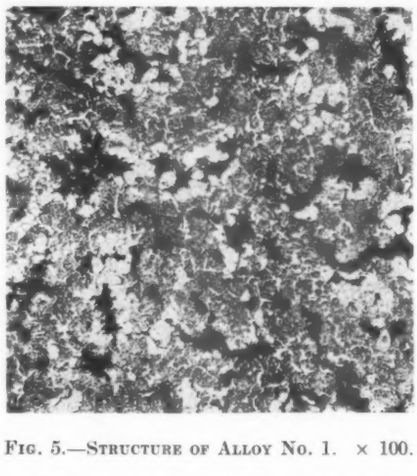

FIG. 5.—STRUCTURE OF ALLOY NO. 1. × 100.

basic iron must of necessity be wholly white in fracture, its carbon being entirely in the combined form. Failure to observe this essential condition will result in difficulties well known to foundrymen. The relationship between carbon content and silicon percentage required must be held to limits which experience chiefly determines.

In the presence of molybdenum, however, basic irons of considerably higher silicon content are usually employed, there being no fear of securing an unwanted mottled fracture. Indeed, sections up to 3 in. can be cast white throughout from molybdenum iron without unduly prolonging the annealing cycle. It has, in fact, been found possible to shorten the annealing cycle in

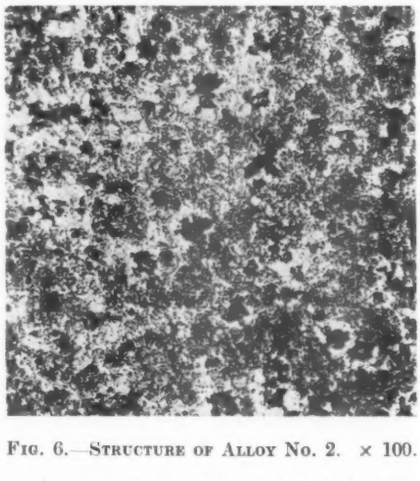

FIG. 6.—STRUCTURE OF ALLOY NO. 2. × 100.

some instances by suitable choice of the silicon and molybdenum concentrations. This double influence of molybdenum in promoting a full cementite or carbide structure in the base iron and in permitting the use of higher silicon contents for more rapid dissociation of the carbide during annealing, is best exemplified in the case of "quick-anneal" malleable iron. By taking proper advantage of these properties, malleable-iron castings of this type can be made with but a 24-hour annealing cycle.

Since molybdenum has a toughening influence, a smaller loss due to breakages in handling white-iron castings may be expected, but the most important foundry advantage obtained by adding molybdenum is that of reducing shrinkage cavities of the type due to gas. It must be admitted that its mechanism in achieving this distinction has not been clearly established, but the fact remains that defects due to gas conditions can be substantially reduced by addition of molybdenum, and have, moreover, been entirely eliminated in some instances on record.

Summary

The observed advantages of molybdenum additions, which have also been confirmed in some instances by independently-conducted researches, may therefore be summarised as follows:—

(1) Variations in chemical composition result in less danger of obtaining mottled iron.

(2) It promotes the production of sounder castings.

(3) Molybdenum produces a tougher malleable iron as well as imparting increased ductility to the basic white iron.

(4) Breakages in handling white iron are therefore lessened.

(5) Molybdenum makes possible the casting of white irons in unusually heavy sections.

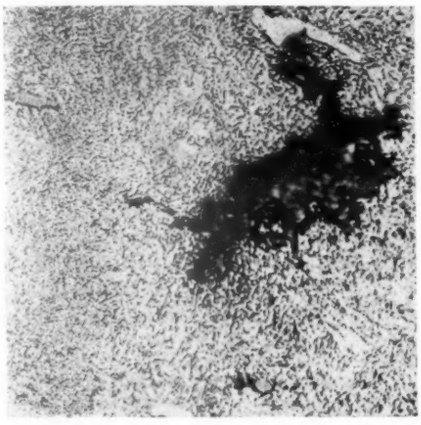

FIG. 7.—STRUCTURE OF ALLOY NO. 3. × 500.

(6) Under certain conditions, molybdenum allows a reduction in annealing times.

(7) Losses due to the cracking of white iron in the moulds may be reduced.

(8) Molybdenum imparts increased tensile strength and ductility.

(9) It enables valuable properties to be secured by suitable heat-treatments.

(10) Molybdenum causes an appreciable refinement in the grain structure.

It may possibly be thought by some that in these articles exaggerated emphasis has been placed on the benefits to be derived from molybdenum additions, but with practical experiences of all types of malleable iron in mind, it is considered that attention might well be given to developments in this direction. Molybdenum additions are too often condemned on the score of expense, but while this attitude may have been justified in some instances, its practical possibilities, foundry advantages, and the benefits of shorter annealings, the potentialities for heat-treatment, and the greatly enhanced physical properties which it undoubtedly conveys, should do much to bring molybdenum as an alloying agent into wider appreciation. Furthermore, attention must be drawn to the fact that recent price movements have brought molybdenum into line with other alloying elements used in ferrous metallurgy, so that objections due to cost, though previously justified perhaps, are now less valid.

The Trend of Research on Foundry Matters

MR. G. L. BAILEY, M.Sc. (Chief Development Officer of the British Non-Ferrous Metals Research Association), gave a Paper on "The Trend of Research on Foundry Matters" at the December meeting of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen. An invitation to attend the meeting was extended to the Electro-depositors' Technical Society. Mr. H. J. Roe (Branch-President) was in the chair.

MR. BAILEY said he intended dealing only with one small branch of the field covered by the title, and to confine his remarks to some directions in which research was assisting in the production of non-ferrous castings for plating. It was important that foundrymen and platers should understand each other's problems. The three headings of his Paper were: Moulding materials, mainly sand; the avoidance of porosity, and deoxidation.

At the conclusion of the Paper, which was illustrated with lantern slides, a film was shown illustrating some researches of the British Non-Ferrous Metals Research Association on the distribution of shrinkage unsoundness and the effect of gases on the soundness of castings.

The BRANCH-PRESIDENT asked Mr. A. J. Shore to propose, and Mr. G. M. Callaghan to second, a vote of thanks to Mr. Bailey for a Paper in which he had raised many interesting points.

Vote of Thanks

MR. SHORE remarked that there seemed a parallel between the problems of non-ferrous castings for plating and those of the founder of grey-iron castings for enamelling.

MR. CALLAGHAN formally seconded the resolution, which was carried with acclamation.

Acknowledging the vote of thanks, MR. BAILEY agreed that there was much that ferrous and non-ferrous people could learn from each other's practice. In its work the Non-Ferrous Metals Research Association frequently came across points in the investigations of other workers on cast iron and steel which had a practical bearing on what was being done in the non-ferrous field.

Deoxidisers for Non-Ferrous Metals

MR. CALLAGHAN, who opened the discussion, pointed out that the lecturer spoke in complimentary terms of phosphorus as a deoxidiser for copper. From time to time his firm had found silicon to be better. They had made many castings for electro plating, and their two greatest difficulties were shrinkage holes due to contraction on solidification and zinc oxide on top of the castings, or pinholes which they ascribed to zinc oxide. Unfortunately, they had to make certain castings for plating as cheaply as possible.

MR. A. A. TIMMINS (Hon. Secretary) said that while Mr. Bailey had expressed the opinion that an increase in the freezing range of an alloy produced an increase in the tendency towards porosity, in regard to cast iron his experience was that an increase in freezing range decreased the porosity.

Dr. Lepp's Work

MR. A. TIPPER recalled that he met Dr. Lepp some five or six years ago, when he came to this country. Apparently Dr. Lepp's process had not been taken up here to any great extent, until recently at any rate. However, he had seen some surprising results therefrom, and believed it was of considerable advantage in getting sound castings from normal moulds. He wondered whether a small percentage of impurities in a plating casting gave poor results or whether plating difficulties were not due to poor plating methods. Could Mr. Bailey say which gave rise to the greatest number of difficulties? It appeared from the general trend of the lecturer's remarks that there were only three main directions in which the founder could improve his products. He thought they could say that the founder was studying that aspect seriously, and it would be interesting to hear from representatives of plating firms present whether, in actual practice, they found that the castings were improving.

Author's Reply

Replying to the discussion, MR. BAILEY pointed out that several speakers had referred to the pre-solidification method. He had mentioned that as one of the early suggestions and not necessarily one of the best methods. It was of considerable interest because to a certain extent it worked, although he entirely agreed with the speakers who pointed out that it was too costly to use in general practice. There appeared to be no danger of cracking the pots on remelting, but aluminium was the only metal so far to which he knew it had been applied. The oxidation of the metal or the oxidation of the atmosphere was a better method with copper alloys. In regard to shrinkage of the metal in the liquid state and shrinkage during solidification, he thought the former was a negligible cause of unsoundness in castings. If it did occur it was the result of unusually bad design. He did not think the foundryman could be altogether blamed for cavities due to solidification contraction, as he was satisfied they did not know enough about this to be able to control it completely. Dr. Lepp's method was mentioned to illustrate an application of the principles of oxidation to which he had referred. In regard to the cheapness of castings for plating, he hoped that platers who appreciated what was involved in making satisfactory castings would also appreciate the fact that, if they wished to obtain really good castings, they must be prepared to pay for them.

Mr. Bailey agreed that the plater could not attribute all his difficulties to defective castings and had his own troubles in the plating operation to contend with, one of the chief of which was porosity, which could be largely overcome by applying a sufficient thickness of coating.

Iron and Steel Production

The British Iron and Steel Federation reports that there were 135 furnaces in blast at the end of November compared with 133 furnaces at the end of October, five furnaces having been blown in during the month and three having ceased operations. The production of pig-iron in November amounted to 762,300 tons, compared with 769,600 tons in October, and 643,100 tons in November, 1936: the month's production included 161,200 tons of hematite, 422,700 tons of basic, 148,200 tons of foundry and 14,200 tons of forge pig-iron. The production of steel ingots and castings in November amounted to 1,178,300 tons, compared with 1,133,600 tons in October and 1,001,300 tons in November, 1936.

Steel production in November is the highest monthly rate ever achieved by the industry. Compared with the previous record of 1,163,000 tons in September, it also represents the largest daily rate of production. The slight recession recorded in October, which was due to the normal loss of Saturday and Sunday shifts, has thus been more than made up. A further important permanent addition to the country's pig-iron capacity features in the November pig-iron returns for the first time. This is the first of two new blast furnaces to be built at the Ebbw Vale Works, South Wales, which although not working to full capacity throughout the month, has largely contributed to the 580 tons increase in the daily rate of output.

AT A MEETING of the Hoffmann Manufacturing Company, Limited, resolutions were unanimously approved increasing the capital from £750,000 to £1,000,000 by the creation of 250,000 £1 ordinary shares. Undivided profits totalling £250,000 are to be capitalised.

X-Ray Examination of Castings

The X-ray examination of materials is steadily gaining ground in all types of fabrication practice by virtue of the fact that it permits non-destructive tests directly on the fabricated article as opposed to the destructive test on a test specimen, assumed to possess the same structural and mechanical properties as the parent material, as adopted in standard mechanical testing practice. The increasing realisation of the value and utility of X-ray tests has not been retarded by the lack of suitable radiography apparatus, and designers have provided a wide range of equipment suitable for use under the most divergent conditions. The potential use of X-rays for the routine testing of castings also has not been neglected, and at the recent Foundry Trades' Exhibition we were able to examine in some detail an X-ray equipment manufactured by Rich. Seifert & Company, Hamburg, the sole United Kingdom selling rights of which are held by Robson Refractories, Limited, of 47, Coniscliffe Road, Darlington. Rich. Seifert & Company manufacture an extensive series of "Isolux" X-ray equipments principally for the examination of welds on steel structures on site, including the apparatus designed for the radiographic inspection of castings which was on show at the Foundry Trades' Exhibition.

This equipment has been specially designed to be run off a normal electric supply and can be connected to a 220-volt mains, two transformers in compact transportable enclosures being provided for boosting up the voltage to 250,000 and even 300,000 volts for supplying the requisite high-tension for the X-ray tube. The equipment includes, in addition to the X-ray tube and the two transformers already referred to, specially-insulated cables for mains connection and interconnection between the various units of the assembly, a foolproof control desk mounted on casters, an adjustable tube stand and essential accessories. The most careful attention has been given to render the whole equipment absolutely shock-proof and radiation-proof, a problem of great difficulty with a compact design of the type on which this equipment is based. Where convenient a radioscopic desk containing the X-ray tube with a fluorescent screen placed at a convenient slope for easy inspection can be used for the direct screening of small steel castings up to about ¾ in. thickness, light metal alloy castings up to 3 in., for aeroplanes, motor cars, etc., as shown in Fig. 1. The composite nature of the equipment considerably facilitates its transport from place to place in a foundry, while control and regulation have been made so easy that relatively unskilled operators can obtain satisfactory results with the apparatus after a little practice. The tubes used are oil-cooled, and suitable for open air work at any time of the year, and a special unipolar tube is provided for testing circular castings, as shown in Fig. 2.

Seifert Isolux equipment is being extensively used *inter alia* by the German National Railways for testing welds on fire boxes, welded or riveted boilers, locomotive frames, welded railway bridges, and other structures; in fact, its application is universal if so required. The tubes generate rays capable of penetrating up to 5 in. of iron or steel, 3 in. of copper, and 12 in. of aluminium or its alloys. A new special feature is the Unipolar tube for photographing by one exposure the welded seams in tubes from a diameter of 1½ in. upwards.

FIG. 1.—ISOLUX X-RAY APPARATUS FOR HIGH TENSIONS UP TO 250 KV., WITH RADIOSCOPIC DESK AND RAIL-STAND USED FOR SCREENING LIGHT-METAL CASTINGS.

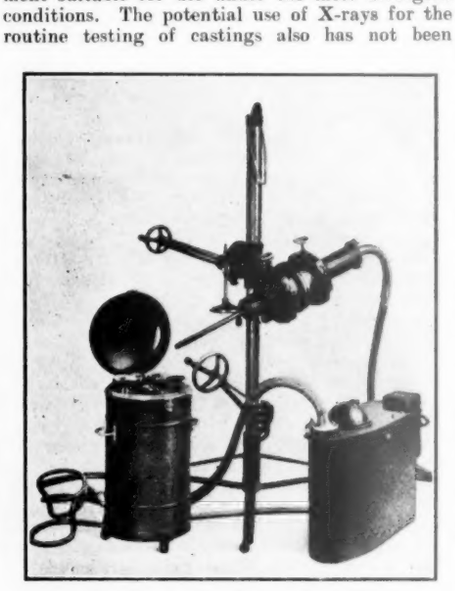

FIG. 2.—X-RAY EQUIPMENT WITH SHOCK-PROOF AND RADIATION-PROOF UNIPOLAR TUBE.

FIG. 3.—SEIFERT-ISOLUX X-RAY EQUIPMENT, RATED FOR 250 KV.; SHOCK-PROOF AND RADIATION-PROOF DESIGN.

Notes from the Branches

Newcastle-upon-Tyne Branch.—At a recent meeting of the Newcastle-upon-Tyne Branch of the Institute of British Foundrymen, the Branch-President (Mr. C. Gresty) presented prizes to successful students who had entered for the John Surtees Memorial Examination. There were 18 entrants in the Junior Section, and the general standard in both the practical and written examinations was particularly high. The Silver Medal was awarded to Mr. J. Slater, an apprentice core-maker, who also received text-books of his own choice. Mr. G. Burn and Mr. Harry McGray were awarded text-books and moulders' tools, respectively.

The BRANCH-PRESIDENT reminded the meeting that the John Surtees Memorial was founded by the late Mr. William Mayer, of Dumbarton, to perpetuate the memory of John Surtees, who was a moulder in the district some 50 years ago. John Surtees was recognised as the pioneer of dry-sand moulding and did a great deal to improve the moulding methods of his day. It is gratifying to note that the work of pioneers is still remembered.

It was announced that the next competition for the Branch would take place early in 1939, and the hope was expressed that the number of entrants would be considerably greater than in the past. Members were also reminded that an examination was open for the Senior Section.

Book Review

Mechanical World Year Book, 1938.—Manchester: Emmott & Company, Limited, 31, King Street West, and London: 28, Bedford Street, Strand, W.C.2. (Price 1s. 6d.)

The 1938 edition of the Mechanical World Year Book, just published, contains an entirely new section on electric-arc welding, which describes the types and properties of electrodes, explains the process in detail, and gives directions for the various methods of welding and for welding in different positions. Welding design is also fully treated, methods of calculation being given for butt and fillet welds. Pursuing the scheme outlined in a previous edition—of alternating sections so that any two consecutive editions provide a greater store of data—there has been brought back into the new edition the section on presswork which was omitted from the edition for 1937. The metals and alloys section has been omitted from the new edition, but will reappear in due course in revised form. General detail revision has been made as usual, and the index has been extended.

Open-Hearth Practices in a Steel Castings Plant*

By JOHN W. PORTER†

The first open-hearth steel melting furnaces for the foundry were characterised by improper design, insufficient steel binding, lack of steel jacketing and insulation, poor and unsuited refractories, and required the invention and application of appropriate control through which operating data could be obtained and applied for systematising the procedure to be followed by a better selected and more educated operating personnel. The operations carried on in that period were further branded with long working days and general inefficiency of both man and equipment.

In the intervening years great improvements have been made in the general technique followed in the production of open-hearth heats. This technique has been developed through the modification of furnace design and through the use of devices for accurately determining the existing conditions during the melting and refining periods.

Modern Improvements

Typical improvements in more or less common use to-day are: (1) Insulation of furnace walls and roof; (2) steel jacketing of walls; (3) use of indicating and recording pyrometers to show the temperature of chequer chambers, of the roof and of the gases in the flues and at base of stack; (4) use of optical pyrometers to determine the temperature of the slag blanket before tapping and of the metal as it either flows into the ladle or into the moulds; (5) use of an indicator of a chequer pyrometer to actuate signal to operator for reversing the flow of gases in the furnace or actually to work an automatic reversing mechanism; (6) maintaining of a predetermined furnace pressure or draft; (7) provision for adjusting the fuel and air valves, so that the proper ratio for combustion is maintained regardless of the rate at which the fuel is required; (8) maintaining of the rate of fuel input constant at the amount required at the several stages of making the heat; (9) the use of automatically controlled fuel preheaters to maintain constant temperature fuel; (10) the use of water-cooled doors, jambs, burner ports and furnace fronts; (11) the production and application of better and more uniform refractories obtained through the research and development of the refractory manufacturers; (12) the use of recording instruments to permit of the supervisor being able thoroughly to check the detailed working of every heat; and (13) the ability of the supervisor definitely to instruct as to the procedure to be followed in every case. In addition to the mechanical devices heretofore listed, the routine of production is further standardised by providing furnace charges in definite quantities and composition of the several items charged. This necessitates the full co-operation of the chemical and yard departments.

The following details pertain to the current basic open-hearth steel refining practices in use at the Granite City Works of the American Steel Foundries for the production of steel for castings:—

The first basic open-hearth heat as produced at the Granite City Works was in 1894. Subsequently, six 25-ton furnaces were built and employed till 1931, when the cumulative improvements in open-hearth practice dictated complete rearrangement of that department.

There are three basic furnaces in use at the present time, into each of which 30 tons is generally charged and refined. The furnaces are known as the Stevens type, and are encased with steel plate on the outside, with the exception of the roof. Between the plate and the brickwork, insulation is used.

Bottom Preparation

Assuming the furnace is complete mechanically and structurally, a small wood fire is started in the stack and in front of each furnace door, with the reversing valves set in the centre to pull both ways to the stack. Care must be taken that the flames do not come in contact with the walls or the roof of the furnace.

As the furnace dries out, the fire is built up to cover the furnace bottom and continued about 72 hrs. Fuel oil must not be turned on until the walls begin to show a reddish colour. At the time fuel oil is turned on the furnace, the consumption should be held as low as possible, with a maximum consumption of 50 galls. per hr.

Care must be taken that the furnace bottom is clean initially. When the fuel oil is turned on the furnace, the reversing valves are taken off centre, and the furnace is reversed after 1 hr. The time of reversals is gradually cut down until at the end of about 48 hrs. the time of reversals is 15 min. It is important that the temperature of the furnace be increased gradually, with a minimum of 48 hrs. to bring the furnace to working temperature, after which the work of building the bottom can be started.

Furnace Bottom

Double-burned magnesite is employed for all new furnace bottoms, being used because it is generally purer than dolomite and has a higher melting point; furthermore, it does not slack as quickly if the furnace is not operated for a period. The magnesite is mixed with ground basic slag in the proportion of three parts magnesite and one part slag. This mixture will be referred to as magnesite mix.

It is important to select slag free from steel and ground as fine or finer than the double burned magnesite. No other bonds of any nature are used with these materials.

A coating of slag is placed on the brickwork before any magnesite mix is used. The material should be spread over the furnace bottom as evenly as possible with layers not over ¼ in. thick, and sufficient time allowed for the material to sinter properly before the next layer is placed in the furnace. For the first 3 in. of bottom placed in the furnace, an interval of not less than 2¼ hrs. should elapse before the next layer is placed in the furnace. After the bottom is 3 in. thick, tests are made at least three times in 24 hrs., by shutting off the fuel oil, allowing the bottom to cool for 30 mins., and striking the bottom with the end of a rod to test the solidity of the material in place.

Control Tests

After the bottom has been built up, until it is about 3 in. thick, about 12 samples of the bottom are obtained in 24 hrs. by a rod properly equipped. After cooling, these samples are broken and the fractures examined for solidity.

The mixture of three-fourths magnesite and one-fourth slag is used on side walls exclusively. Some slag will flow out of the mixture to the furnace bottom. Magnesite without slag is used to fill in the furnace bottom and absorb this excess slag. The proportion of slag in the mixture should be adjusted to produce a solid bottom.

The practice of taking samples is continued until the bottom is complete, the layers of magnesite mix are continued until the level of the tapping hole is reached, and the time necessary to build a bottom in a 30-ton basic open-hearth is about six days.

A pipe 6 in. in diameter and of the correct length is placed in the proper position for the tapping hole and held in place by blocking where the tapping hole passes through the wall of the furnace. The part of the pipe inside the wall of the furnace is covered with a layer of magnesite mix 1 in. thick, and the end which extends inside the furnace bottom line is covered with magnesite mix to prevent the pipe melting. The pipe is closed by filling the inside with either magnesite or burnt dolomite, as though it were closed for a heat.

The layers of magnesite mix are continued up the side of the furnace to a point about 10 in. above the slag line. The furnace bottom must be arranged so that the steel and slag will all drain out of the furnace when the tap hole is opened.

On the tapping hole where the pipe was blocked in the furnace wall to keep it in position, the brick used for blocking is removed and replaced with a mixture of three parts of ganister or chrome and one part of clay, with enough water to make the mixture pack well. This mixture is rammed as hard as possible, and the space between the tapping hole casting and the pipe in the wall of the furnace is completely filled. The tapping hole is cleaned out and reclosed as though a heat were to be charged.

Ground slag is charged into the furnace, placing this as high as possible on the sides of the furnace, using the same methods used to place material for the bottom. This is repeated after approximately 1 hr. and continued until there is a depth of 2 to 6 in. of liquid slag on the furnace bottom. The liquid slag is splashed as high as possible on the walls and ends of the furnace to allow the magnesite to absorb as much as possible of this liquid slag. The time allowed for this slagging bottom should not be less than 5 hrs.

The slag is then tapped and the furnace is ready for the first heat. Before charging the furnace, the furnace bottom is chilled by opening the doors and cutting off the fuel, the time used for chilling the furnace being left to the judgment of the melters.

Tapping Hole

The tapping hole is closed by holding a rabble against the end in the furnace. Bottom material is inserted from the outside and firmly packed in place until the tap hole is filled to about 6 in. from the end. This space is filled with loam moistened with sufficient moisture to make it pack well. The rabble is removed from the inside of the tap hole and some bottom material placed over the end of the tap hole by shovelling through the door of the furnace.

Furnace Runner

The furnace runner is lined with clay brick and then mudded with loam moistened with water to the proper consistency so that it packs well. This mud is renewed after each heat. The runner is dried to remove all moisture before the heat is tapped. In making up the furnace charge, consideration should be given to the available material, chemical analysis, price, and space required in the furnace. In arranging the furnace charge the standard shown in Table I is sought.

Burnt lime is used in place of limestone for two reasons: (1) the time element in melting, and (2) the need for less initial carbon content in charge. Additional lime may be added to the bath when necessary to condition the slag.

Charging

The material should be charged in the following order: (1) Scrap, (2) petroleum coke and manganese ore, (3) lime, (4) scrap, except rails, (5) rails, and (6) pig-iron. The first material charged into the furnace on each heat should be selected with a purpose of covering the bottom of the furnace and furnishing a bed for

* "Iron Age" report of a Paper presented at the foundry conference sponsored by the American Foundrymen's Association, the St. Louis Chapter of the A.F.A., and the Missouri School of Mines, at Rollo, Mo.

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the lime, thus preventing the lime from sticking to the furnace bottom. Plate scrap is probably the best for this purpose. Lime should be spread as evenly as possible over the first scrap charged.

Draft

The furnace should be arranged with two sources of draft, a fan to force air into the furnace and a stack to draw air out of the furnace. The amount of air admitted to the furnace is controlled by the diaphragm, which also controls the fuel oil. The stack is provided with a damper and manometer, so that the proper conditions and balanced pressure can be maintained in the furnace.

The draft in the furnace at the downtakes should be about 0.07 in. on the outgoing end, and about 0.05 in. on the incoming end. It is necessary to have a slight plus pressure in the furnace to avoid cold air entering the furnace. When the final additions are made, the draft is reduced to 0.04 in. in the stack.

The fuel oil and steam are cut down at the same time. This condition is maintained until the heat is tapped. A reduction of draft, fuel oil and steam at the time of making the final additions is recommended, because this condition cuts down the amount of oxidation of the metal and thus there is less loss of manganese and carbon, and of chromium when used.

TABLE I.—*Furnace Charge, Analyses and Weights.*

	Analyses. Per cent.	
	As charged.	As melted.
C	1.75 to 2.0	0.65 to 0.75
Si	0.50 max.	0.03
Mn	1.40 to 1.50	—
S	0.045 max.	?
P	0.065 max.	?

	Typical charge.	
	Weight in Lbs.	Per cent. of Total.
Pig-iron	12,000	20.0
Company scrap	6,000	10.0
Plate scrap	22,500	37.5
Rails	11,000	18.5
Forgings	4,500	7.5
Springs	4,000	6.5
Total	60,000	100.0
Tar coke	—	300 lbs.
Burnt lime	—	2,600 lbs.
Manganese ore	—	600 lbs.

Fuel Oil

Fuel oil of a gravity of 5 to 12 deg. Baumé is used, at a temperature of 170 to 190 deg. Fah. when it enters the furnace. A preheater is used for the oil before it enters the burner. The amount of fuel oil being burned per hour is indicated and recorded. The amount of fuel oil necessary cannot be definitely stated, but can be determined by experience for each furnace and, after being determined, should be followed closely. One hundred and twenty to 130 galls. per hr. after charging is the average consumption.

The fuel-oil rate of flow is reduced when the heat is melted, and the melter must exercise his own judgment on this question. On heats which melt very hot, the consumption of fuel oil may be cut down as low as 80 to 90 galls. per hr. when the final additions are made.

Steam

The use of superheated steam for atomising the fuel oil gives assurance of dry steam. The temperature of the superheated steam at the regulator should be 600 to 700 deg. Fah. The pressure should be 55 to 60 lbs. at the regulator. This is maintained until the heat is melted, and when melted the steam pressure is adjusted to the conditions in the furnace, depending on the judgment of the melter in charge. When the final additions are made, the steam pressure is reduced and a soft rolling flame is held until the heat is tapped.

Slag

The furnace charge should contain sufficient lime to remove the impurities in the metal and furnish protection to the metal from an oxidising flame. Whenever it is necessary to use fluorspar to condition the slag, the amount should be held to a minimum.

Refining

During charging and until the lime starts to come up, the furnace should be run with a full flame, predetermined settings being maintained by the instruments. The temperature of the bath at the time the charge is melted should be high enough gradually to cut down the fuel oil, air and steam, and by this practice some manganese and chromium reverts to the steel from the slag.

As soon as the heat is melted and the lime is up, which is indicated by the absence of localised violent boiling action in the bath, a spoon test of the metal should be taken, the melter judging the carbon content by the fracture. Upon the carbon content the melter bases his judgment as to the amount of iron ore to add, and also to the time it is to be used. The heat should be at a fairly high temperature and the slag should be in a mushy condition.

After the iron-ore addition, the bath will break into a brisk boiling action, which should gradually slow down to a uniform gentle boiling action over its entire surface, the boiling action becoming less intense and the carbon drop less rapid as the bath approaches a carbon content of 0.25. During this time the amount of fuel, air and draft should be gradually diminished but still keeping a plus pressure. The slag should be assuming a creamy condition. Iron ore should not be used until the slag is in a mushy condition.

Preliminary Tests

Tests are taken by first slagging the spoon thoroughly, then thrusting it down into the steel, withdrawing it and pouring the steel into a test mould. The test should be cooled slowly and all tests given approximately the same treatment, or variations in the results of the analysis may be expected when the laboratory uses the colour method of analysis.

On the first preliminary test the chemical laboratory determines the carbon, manganese, sulphur and, on chrome heats, chromium. On all subsequent tests the chemical laboratory determines the carbon and manganese. Other tests are taken as the refinement of the metal proceeds.

Additions for Certain Heats

Ferro-silicon (15 per cent.) should be added to the bath 10 min. before tapping. Ferro-manganese (80 per cent.) is usually divided. Ground 80 per cent. ferro-manganese is added through a shute over the furnace runner, usually 100 lbs. per heat when this quantity is available; the balance should be added to the bath 3 min. before tapping. Where no fines are available, it is satisfactory to use lump 80 per cent. ferro-manganese through the furnace.

The quantity of the ferro-manganese charged should be adjusted, the amount used depending on the residual manganese in the bath as shown by the preliminary tests. The ferro-manganese charged in the furnace should be moistened to assist it in passing through the slag, and if any lumps should hang in the slag it is satisfactory to push them through with a rod. The ferro-manganese added in the shute should be broken into pieces that will go through a $\frac{1}{2}$-in. screen.

All of the 50 per cent. ferro-silicon should be added through a shute over the furnace runner. The material should be broken into pieces that will pass through a $\frac{1}{2}$-in. screen.

Finishing and Tapping

When the final additions are made, the draft is cut down. The amount of fuel oil burned and steam used for atomising is reduced as much as possible, and this condition is maintained until the heat is tapped.

The material used to close the tap hole should be removed from the outside, leaving only a few inches of material on the inside. The tap hole and the runner should be thoroughly cleaned before proceeding. A tapping rod should then be inserted through the observation hole in the centre door of the furnace, slagged, and after locating the tapping hole, the rod is thrust endwise against the material left in the tap hole until the rod pushes through and allows the heat to run out of the tap hole into the ladle.

Ladle Additions

When the metal in the ladle is approximately 1 ft. deep, the bottom of the shute over the runner is opened, allowing the material in the shute to run into the stream of metal as it runs from the furnace into the ladle.

The chemist's report of the carbon and the manganese in the final preliminary test is usually received too late to make adjustments of the addition charged into the furnace. The adjustments required are, therefore, made in the materials charged in the shute over the furnace runner.

Bottom Repairs

Furnace bottom should be maintained in good condition. This can be accomplished by proper care. After a heat is tapped, the furnace bottom should be free from pools of slag or steel. When the bottom becomes uneven, due to lime adhering to it or due to portions of the bottom materials becoming loosened by the action of the bath, the pools should be splashed or rabbled out so that the slag or steel will drain out at the tap hole.

When a large or deep hole occurs in the bottom, care should be taken to rabble it out clean, then dry it up with bottom materials. After drying, the hole is to be filled with bottom material, each addition being sintered until the hole is built up to the bottom level. After all the pools have been rubbed out and filled in with bottom material where this is necessary, slag should be shovelled in, in front of the tap hole to stop the flow of slag into it. The tapping hole is then filled in from the outside with bottom material, which should be rammed in tight. The slag line along the back wall and ends is then made up by throwing bottom material on it with a shovel. The front wall is made up by placing bottom material on it with a spoon.

The contour of the bottom along the back wall and the opening into the tap hole must be maintained, so that when the tap hole is opened the slag will not run out until the steel is practically all out.

At the end of each week, when the last heat has been tapped the furnace should be run hot so as to slag the bottom and two or more slag heats run off depending on the bottom condition. The bottom should not be made up again until within 1 hr. of charging.

The diameter of the tapping hole should be maintained as close as possible to 6 in. When repairs are necessary a 6 in. pipe should be placed in the hole and the space around it filled in with a mixture of ganister or chrome and cement. The furnace bottom should always provide for a bath depth of 22 in., the measurement to be taken at the centre of the furnace.

Conclusion

By the use of a uniform charge from heat to heat and by the control of refining operations, it has been possible consistently to produce the highest grade of steel of required compositions, physical properties, and other qualities.

Modern Views of Cast Iron*

By A. L. NORBURY, D.Sc. (British Cast Iron Research Association)

Introduction

The title of this Paper possibly admits of more than one interpretation, but the one which is put forward in what follows is that: Cast iron is an alloy the microstructure and properties of which, on solidification, can be greatly affected by "inherent properties" or conditions in the molten metal which are not revealed by ordinary chemical analysis. It is now thought these "inherent properties" result from the presence or absence in the molten metal of large numbers of minute solid slag particles such as silicates, etc. Such particles are so small that, although their number may be of the order of one million per cubic inch of molten metal, their weight is only of the order of 0.1 per cent. of the molten metal. They are at present difficult to separate and estimate by chemical analysis, but may be readily seen under the microscope. (For example, cubic particles, $\frac{1}{1000}$ in. in width across the cubic face would appear large, *i.e.*, 1 in. in width at 1,000 magnifications, but 1,000,000 of such particles per cubic inch of metal would only occupy

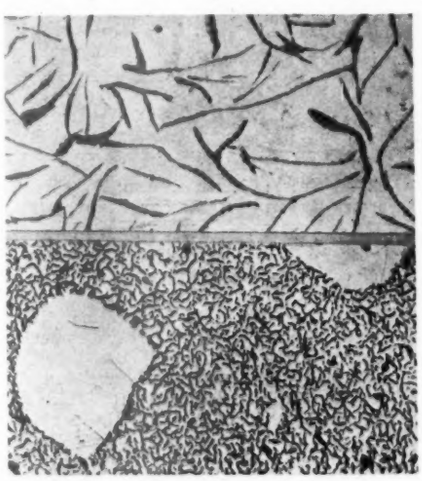

FIG. 1.—A (TOP): COARSE GRAPHITE, AND B (BOTTOM): FINE GRAPHITE IN HEMATITE IRONS. × 200.

$1{,}000{,}000 \times (\frac{1}{1000})^3$ cubic inches = 0.1 per cent. of a cubic inch. Such particles would be $\frac{1}{100}$ in. apart between centres.)

In what follows it is proposed first to show the different microstructures that can be obtained in irons of the same analysis, and to indicate the way such differences may be produced, and to outline the theory which has been put forward to explain them; secondly, to show how the mechanical and physical properties of the metal are affected by such differences, and thirdly, to show that certain other alloys are affected in a similar manner.

Different Graphite Formations in Cast Irons of the Same Analysis

Fig. 1A shows at 200 diameters an ordinary hematite (*i.e.*, non-phosphoric) cast iron containing T.C 3.5, Si 2.5 and Mn 0.75 per cent., cast into a 3 in. diameter bar in a sand mould. The structure consists of black flakes of graphite in a steel-like matrix in which the silicon, manganese and some carbon is dissolved. Fig. 1B shows, at the same magnification, metal from the same crucible melt after it had been treated in the molten state, before casting, by adding 0.2 per cent. titanium and oxidising the titanium by bubbling carbon dioxide gas through the molten metal.[1] The analysis, apart from the 0.2 per cent. titanium, was unchanged, and the casting conditions were the same, but it will be seen that the graphite flakes are very much finer. Similar differences in graphite formation in two phosphoric irons having practically identical analyses (T.C 3.6, Si 1.6, Mn 0.8, S 0.07 and P 1.1 per cent.), apart from the titanium, are shown in Figs. 2A and 2B, also at 200 diameters. Uniform-sized graphite structures of intermediate size can be obtained between the extremes shown in Figs. 1 and 2, also non-uniform, *i.e.*, mixed sized structures. The latter are the ones most usually obtained in commercial castings.

Theoretical Explanation of Conditions which Affect Graphite

The theory put forward[2] to explain these differences is that the coarse graphite structure is produced when *solid* non-metallic inclusions, such as silicates, are present in the molten metal, when the temperature (1,140 deg. C.) is reached at which the graphite separates out from the molten metal, and that solid inclusions assist and initiate the solidification of solid graphite. When solid inclusions are not present, due to the melt being free from inclusions or due to the inclusions it contains being still liquid at 1,140 deg. C., it is assumed that the solidification of the graphite does not occur when it should, but undercools to a lower temperature, at which it separates and solidifies in a much more finely divided state.

It is assumed that the action of titanium and oxidation is to change the silicate slag inclusions to silicate-titanate slag inclusions of lower melting point, so that they are still liquid when the graphite is due to solidify. Kish has a coarsening action.

Moreover, if the molten metal in the above (fine-graphite forming) condition is subjected to reducing conditions—for example, by treating with hydrogen—a coarse graphite structure is formed. The suggested explanation is that FeO is reduced to Fe, and the melting point of the slag inclusions consequently raised. Melting in contact with coke also tends to produce the same effect, which makes the production of fine-graphite iron more difficult in the case of cupola melting, as discussed below.

Production of Fine-Graphite Formation

The fine-graphite structure can be produced as above, and is also produced if cast irons are made from very pure synthetic materials melted *in vacuo*—as found by Hanson[3]—the resulting melts being inclusion-free. It is also produced, as found by Piwowarsky[4] and others, by superheating the melt to 1,500 deg. C. or over, which is assumed to cause the decomposition of silicates to silicon by carbon, the result being again an inclusion-free melt.

From the practical point of view, however, the presence in the pig-iron of titanium, with its graphite-refining effect, is the most important. Hematite pig-irons in this country normally contain below 0.1 per cent. titanium, and this is not enough to refine the graphite. Phosphoric (*e.g.*, 1.5 per cent. P) irons, however, contain round about 0.2 per cent., and this may be enough if the melting conditions are oxidising. A Norwegian pig-iron, known as "Vantit," contains up to 0.6 per cent. titanium, and gives completely refined graphite structures if melted under oxidising conditions with sufficient steel to prevent kish formation.

In crucible melts the fine-graphite structure can be produced in any composition (unless aluminium or certain other elements are present) and from nearly all pig-irons by treatment with titanium (ferro-silicon titanium) plus carbon dioxide. About 10 per cent. steel must usually be added to reduce the carbon content so that kish is not formed. Sufficient titanium in the pig-irons in the charge makes addition of titanium unnecessary.

The treatment of ordinary cupola metal in the ladle is, however, usually unsuccessful, partly owing to the temperature falling, but mainly owing to the fact that during passage down the cupola, reduced silicate inclusions form in the metal which prevent the required composition of titanium inclusions being formed. Rotary furnaces tend to give intermediate results between crucible and cupola furnaces from the above point of view.

The production of fine-graphite castings by melting titanium-containing charges in the cupola is, owing to the coke contact, less easy than melting the same charges in the crucible, but work carried out by Mr. E. Morgan shows that it can be done if the cupola is operated suitably. Most commercially available pig-irons do not contain sufficient titanium to refine in this way, although, as stated above, some of

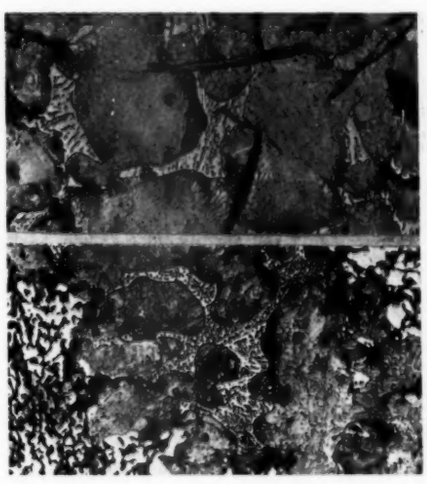

FIG. 2.—A (TOP): COARSE GRAPHITE, AND B (BOTTOM): FINE GRAPHITE IN PHOSPHORIC IRONS. × 200.

the phosphoric pig-irons contain nearly enough. (Incidentally, some of the hematites made some years ago did contain sufficient.) If, however, pig-irons were available in hematite or phosphoric compositions, containing 0.2 per cent. or more of titanium in the right form, it is thought that there would be little difficulty in producing the fine graphite from cupola melts, at all events, it could be produced in not too thick sections. (It will be noted that it follows from the above that the titanium content of a pig-iron is not necessarily an exact guide to the ease with which it will refine, since the titanium may be in the form of inclusions of the wrong sort. For example, treatment with hydrogen gives coarse fractures even when titanium is present.)

Production of Coarse-Graphite Formation

The coarse-graphite structure, on the other hand, is formed when the silicon in inclusion-free melts is allowed to oxidise; by adding aluminium and oxidising it, or by adding calcium silicide. In the latter case it is suggested that high melting point calcium carbide particles are formed, since this reaction is known to occur and the fractured iron smells strongly of acetylene. If *low total carbon* irons are "inoculated" in this way, the uniformly coarse graphite structure (Fig. 3A) gives higher strength than the mixed fine and coarse structure (Fig. 3B) more ordi-

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* Paper read before the Manchester Metallurgical Society, Mr. J. L. Herbert presiding.

1 The process has been covered by B.C.I.R.A. British and foreign patents.

2 Norbury and Morgan, Journal of the Iron and Steel Institute, 1936, II, pp. 327-358.

3 D. Hanson, Journal of the Iron and Steel Institute, 1927, II, p. 129.

4 E. Piwowarsky, Transactions, American Foundrymen's Association, 1926, Vol. 34, pp. 914-985.

narily obtained. (Figs. 3A and 3B are discussed later in connection with Table I.) High-strength Meehanite and Ni-tensyl grey cast irons are produced by this type of "inoculation" process. Ordinary cupola metal usually contains mixed graphite structures, which are chiefly coarse in the case of hematite melts and chiefly fine in the case of phosphoric iron melts on account of the difference in their titanium contents. The size, of course, also depends to a large extent on the section.

It must be emphasised that these differences of graphite size are not merely of academic interest. They are of great practical interest, since variations are liable to occur from day to day in any foundry, resulting from differences in the type of charge used to get the same final analysis, and differences in the way the cupola is working, for example, whether oxidising or reducing. Such differences will not, of course, be as extreme as those shown in Figs. 1A and 1B, or 2A and 2B, but may be sufficient to have quite a considerable effect on the properties of the metal.

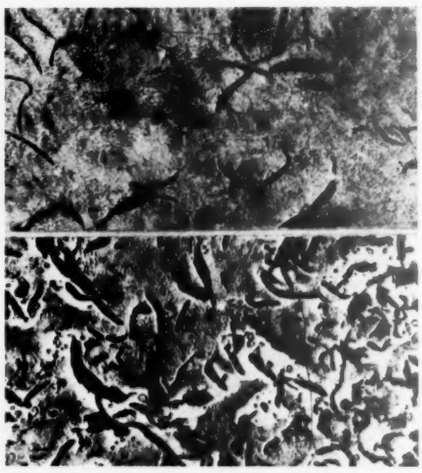

FIG. 3.—A (TOP): COARSE GRAPHITE, AND B (BOTTOM): MIXED GRAPHITE IN LOW TOTAL-CARBON NON-PHOSPHORIC IRONS. × 200.

Effect of Graphite Formation on Properties of Grey Cast Iron

Considering now the differences produced in the *properties* by the coarse and the fine-graphite formation in cast iron:

(*a*) *Strength.*—The effect on the strength is complicated. The tensile strength of the very coarse iron shown in Fig. 1A was 7½ tons per sq. in. and that of the fine iron shown in Fig. 1B was 19½ tons per sq. in. The fine-graphite irons are, however, only considerably stronger than the coarse if the latter are very coarse and high in total carbon. In the lower total carbon irons there is not much difference in the strength figures and the coarse may even be stronger, since the coarse graphite flakes, if few and far between, are not sufficiently continuous to weaken the iron to the same extent as do those in a high total carbon iron as shown in Fig. 1A. A further complication regarding the strength is that a mixed fine and coarse structure (Fig. 3B) in a *low total carbon iron* gives a lower strength than either a uniformly fine or a uniformly coarse (Fig. 3A) as shown in Table I. It will be noted that the mixed flake formation in Fig. 3B offers more continuous lines of weakness than does that in Fig. 3A.

(*b*) *Fracture and Phosphide Network Formation.*—The coarse graphite formation gives the usual grey fracture containing shining black graphite flakes in high carbon compositions. The fine graphite gives a close sooty black fracture like blackheart malleable, and a honeycomb network formation of the phosphide which becomes increasingly evident as the phosphorus content increases. This phosphide network formation, which is a characteristic of fine graphite formation, was first noted by F. J. Cook, whose work[5] on its foundry production from cupola melts by the use of certain selected pig-irons (titanium-containing) and by operating the cupola in a certain manner, is of special interest in relation to the commercial cupola production of fine graphite castings discussed above. His high strength figures for the composition of cast iron used are also very significant.

TABLE I.—*Cast Irons A and B of the Same Analysis and Different Mechanical Properties.* (1.2-*in. Dia. Sand-Cast Bars.*)

	A.	B.
T. C .. .. .. Per cent.	2.94	2.91
C. C .. .. .. „ „	0.80	0.62
Si .. .. .. „ „	1.70	1.82
Mn .. .. .. „ „	1.00	0.67
S .. .. .. „ „	0.03	0.03
P .. .. .. „ „	0.03	0.03
Transverse strength (tons per sq. in., 18-in. centres)	39.8	23.1
Tensile strength (tons per sq. in.) ..	23.4	14.4
Repeated impact (No. of blows to fracture)	3,476	68
Brinell hardness (10/3,000/30) ..	241	207

(*c*) *Combined Carbon Content and Wear.*—The fine-graphite formation tends to give a lower combined carbon content than the coarse and has poor wearing qualities, especially in low phosphorus irons, steps being taken to avoid its formation in the manufacture of piston rings, etc. If, however, the combined carbon were to be kept up by heat-treatment or altering the composition, the fine graphite might not prove disadvantageous in such applications. The fine graphite machines more easily and gives a much better finish.

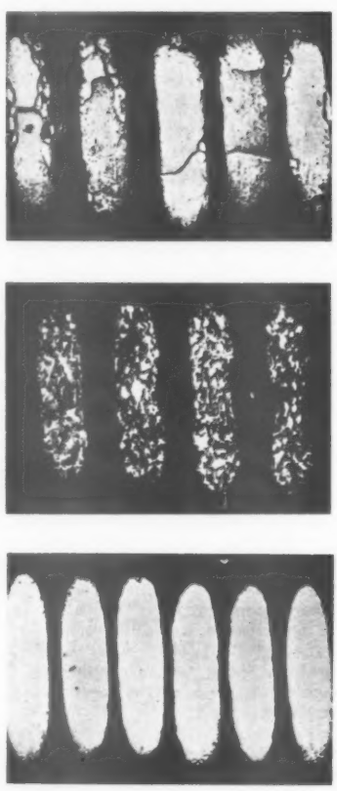

FIG. 5.—COILED TUNGSTEN FILAMENTS PREPARED FROM OXIDE CONTAINING: TOP, LESS THAN 0.2 PER CENT. IMPURITIES; MIDDLE, 0.7 PER CENT. THORIA; BOTTOM, 0.2 PER CENT. NaCl, 0.3 PER CENT. KCl AND 0.4 PER CENT. SiO_2. (FROM SMITHELLS' "IMPURITIES IN METALS.")

(*d*) *Soundness and Fluidity.*—Work recently carried out by Mr. A. A. Timmins, of the B.C.I.R.A., and not yet published, has shown that in phosphoric (1.2 per cent. P) cast irons the fine graphite formation has remarkably greater freedom from porosity; the fluidity was also found to be greater.

(*e*) *Growth, Corrosion, Enamelling Properties and Electro-Plating.*—The fine-graphite structure is more resistant to growth or internal oxidation down the graphite flakes, and also to certain types of corrosion, especially when accompanied by a phosphide network. To other types of corrosion it has been found to be inferior. It has been found to have better vitreous enamelling and electro-plating properties.

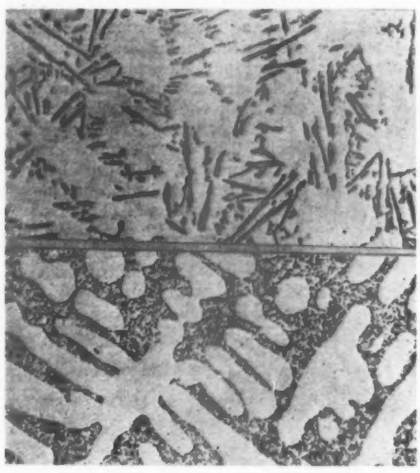

FIG. 4.—A (TOP): NORMAL, AND B (BOTTOM): MODIFIED ALUMINIUM SILICON ALLOY. (FROM GWYER & PHILIPS, J.INST.MET., 1926, ii.)

Consequently, for many purposes, the fine-graphite structure is desirable; for other purposes, however, it is undesirable. (It should also be mentioned that in phosphoric irons it tends to produce phosphide sweat on the surface of the castings. This, however, can be avoided by altering the composition so that the manganese is not quite sufficient to neutralise the sulphur present—which, incidentally, increases the combined carbon. Alternatively, if the graphite refining is not carried to completion, the phosphide sweat will not result.) In any case, the ultimate aim must be to be able to control the graphite formation and produce at will, coarse, intermediate or fine graphite structures, according to which have been found to give the best results in a given application.

Refining of Structures in Other Alloys

Consider now the variations in structure in other alloys—in some cases of a very similar sort—in other cases of a different sort—but in all cases produced by non-metallic inclusions. Fig. 4 shows normal and modified aluminium-silicon alloy structures, and their similarity to cast irons is evident. The aluminium-silicon alloy is modified by adding about 0.1 per cent. sodium which, it is suggested, is precipitated from the molten metal during cooling as fine liquid particles which precipitate on the *solid* particles of Al_2O_3, etc., present, and coat them with *liquid* and prevent them "inoculating" the silicon solidification. Copper in excess of its liquid solubility at the graphite eutectic solidification temperature, has a similar refining effect on the graphite in cast iron. Incidentally, it is not suggested that this effect of inclusions occurs in all eutectic alloys; it apparently only occurs in certain types.

That non-metallic inclusions may affect the grain size of metals is shown in Fig. 5, which

[5] F. J. Cook, Proceedings of the Staffordshire Iron and Steel Institute, 1909-10, p. 102.

shows the effect of thorium oxide in tungsten wires. This effect on the *solid* crystallisation is obviously not directly comparable with the effect on the solidification of eutectics from the *liquid* state, but what they have in common is that they are both due to minute quantities of non-metallic inclusions. The effect of aluminium oxide in producing fine grained "abnormal" steels (Fig. 6) —assuming this is the explanation of the production of fine-grained steels by the addition of <0.1 per cent. aluminium—is another example of grain refinement by solid non-metallic inclusions. The fine pearlite rim in whiteheart malleable,

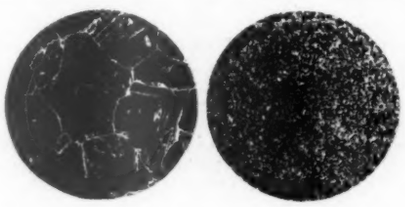

FIG. 6.—(LEFT) COARSE, AND (RIGHT) FINE-GRAINED STEEL. × 35. (FROM A.S.T.M. STANDARD GRAIN SIZE CHART, E19-33T.)

shown in Fig. 7, is, it is suggested, also due to the effect of silicate, etc., inclusions formed by oxidation penetration.

As another instance, the graphide nodules in malleable iron usually contain non-metallic inclusions at their centres, and there is considerable evidence to show that such inclusions help to initiate the deposition of temper graphite on annealing.

The above are all put forward as instances in which the microstructure, and consequently the

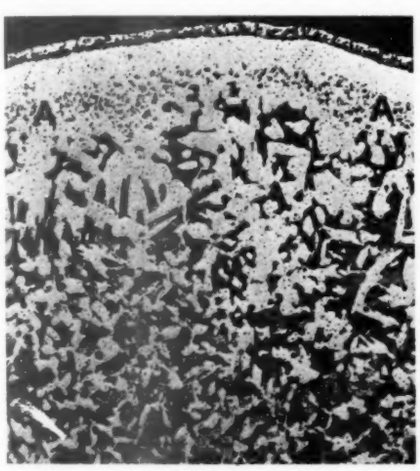

FIG. 7.—EDGE OF WHITEHEART MALLEABLE. × 35. NOTE FINE-GRAIN RIM AT A.

properties, of any alloy are affected by traces of impurity in the form of non-metallic inclusions, whose presence and influence have only recently been realised. It is evident that many other alloy systems and non-metallic systems must be influenced in a similar sort of manner.

DISCUSSION

The Al-Si Modification Analogy

PROFESSOR THOMPSON wished the lecturer to amplify his remarks regarding corrosion. There seemed to be many points for which alternative explanations could be found, but different alternative explanations were required to explain each of the experimental effects. The analogies which Dr. Norbury had drawn between the modification of the aluminium-silicon alloy and the modification of the cast irons were fundamentally sound. He would have felt happier about the explanation if it had not been for the fact that it was possible to modify aluminium-silicon alloys with materials other than sodium, such as alkalis, which the explanation provided hardly seemed to fit. In connection with the fine-grained pearlite and the oxidised steels, it was by no means improbable that oxygen in solid solution might be responsible. The problem was one of unusual difficulty. Granted the importance of the non-metallic inclusions which were present, he still found difficulty in visualising a process which explained all the facts. It was particularly difficult to understand why the mere fact that certain inclusions were liquid, whereas other inclusions were solid, showed such marked differences in microstructure. He had pleasure in proposing that the very best thanks of the meeting be accorded to Dr. Norbury for his lecture.

MR. R. A. JONES (President of the Lancashire Branch of the Institute of British Foundrymen) seconded the vote of thanks.

Corrosion of Cast Iron

DR. NORBURY, replying to Prof. Thompson, said the corrosion problems of any metal were very complex, especially of cast iron, for there were the complications in the cast iron in addition to the complications of corrosion. The general view was that differences in composition of cast iron, in the ordinary way, were not very important. If a corrosion-resisting iron was desired then a special iron such as "Ni-Resist" was necessary, which contained 14 per cent. nickel and 6 per cent. copper, or alternatively a 15 per cent. silicon iron was used which was even resistant to sulphuric acid. From the point of view of graphite size, probably the fine-graphite flakes would produce more centres from which corrosion could start. On the other hand, in a phosphoric iron, if the irons had a fine-graphite structure, the phosphide was present in what was known as a network structure, forming a honeycomb in the metal. In a coarse-graphite iron, the phosphorus was not in a honeycomb structure, and such differences might have an important effect on corrosion. The honeycomb form of phosphide was probably much more resistant to corrosion. For example, it should hold up the form of internal corrosion known as graphititis which gave a corrosion product of cast iron which could be cut with a knife although the casting might preserve its original appearance. Under other conditions of corrosion it had been found by Piwowarsky that the fine graphite was not as good as the coarse.

"Modified" Structures

Professor Thompson had referred to the fact that aluminium-silicon alloys could be modified by means of certain hydroxides. He believed the action was that sodium hydroxide changed into metallic sodium and then had the effect he had suggested. There were also other modifiers for that particular alloy and their action was usually similar to that of sodium. Professor Thompson had referred also to the fine-grained steels, suggesting that oxygen in the metal might cause the effect. The theory of fine-grain formation in steels was at present a matter of considerable debate. Some recent work in America was, he thought, very suggestive. What was done was to put in 1.0 per cent. of aluminium in one steel and 0.1 per cent. of aluminium in another and have a third steel with no aluminium at all. These steels were made under such conditions that the aluminium could not possibly have become oxidised. They were melted in a vacuum furnace and oxygen was kept out of the metal from the start. Under these conditions the aluminium had no effect on the grain size of the steels. When, however, the aluminium-containing steels were annealed under oxidising conditions, a fine grain effect appeared on the outside and progressed inwards as the oxidation progressed inwards.

Influence of Furnace Conditions

Replying to Mr. Jones, DR. NORBURY observed that he quite agreed that the way metal was melted might have an effect on its properties. Melted hot, it had different properties from when it was melted cold. He instanced two cupolas of different design working side by side and melting similar charges. One of the cupolas produced a slightly, but definitely larger, percentage of wasters than the other. This was remedied when that cupola was changed to a similar type as the good one. Phosphoric iron could give sound castings in regard to porosity, if the right type of charge and the correct way of melting in the cupola were used. The reason that the research referred to on porosity was commenced was that variations were found in castings in regard to porosity from day to day, which were not explained by differences in ordinary chemical analysis.

The Surface Tension Factor

MR. E. L. RHEAD said that reference had not been made to the possibility of surface tensions existing in the material affecting the fineness of the graphite. He was of opinion that surface tension, to a large extent, affected the final result. Some years ago he pointed out that by modifying the structure, irons with a strength of 20 tons per sq. in. might be obtained. The irons with which he was then working contained rather more than 3 per cent. of carbon. A series of examples was produced in which the strengths varied from 10 tons per sq. in. to nearly 20 tons —19.8 was the exact figure—and that without using titanium. Was it quite certain that graphite was actually being precipitated in that form, or were they getting down a eutectic, and, though the particles present might be of that nature (graphite), they were actually a decomposition product?

DR. NORBURY said that Mr. Rhead suggested the graphite size effects were due to surface tension, but one had to go a step further than that, and explain where and how the surface tension effect arose. The surface tension of a solid and of a liquid inclusion was vitally different. Mr. Rhead might be thinking along the same lines as himself.

Dr. Norbury added that the test-bar series mentioned by Mr. Rhead was very interesting. He did not pretend that the variation in properties of cast irons of the same composition was anything new. It had been said by practical foundrymen, for many years, that cast irons of the same analysis could have different properties. The chemists had said that was impossible, but their analyses were incomplete, since they did not give the non-metallic inclusions present. In the case of the aluminium-silicon alloys, there was no question of an inter-metallic compound corresponding with iron carbide being formed, and there was consequently no question of the fine structure in the aluminium-silicon resulting from the decomposition of an inter-metallic compound.

Replying to further questions, Dr. Norbury said that, with respect to the use of copper as a modifying agent, they had tried out one or two cupola melts, putting in about 8 per cent. of copper, and had obtained a fair measure of success. There was considerable refining of the graphite, but there were objections to the use of copper, and, at something like £40 a ton, it was in comparison a fairly expensive material. Cast iron was so cheap that it could less easily bear the cost of more expensive additions. From the practical point of view, the titanium method was more likely to be of use. Experiments did show that excess copper would refine an iron containing alumina. Moreover, if hydrogen was bubbled through iron modified by copper, the fine-graphite structure was not coarsened. With regard to the effect of aluminium on the grain size of steel, the point was that unoxidised aluminium did not refine the grain size of the steels, but that when they were annealed in oxidising conditions, oxygen started to enter into the steel, forming aluminium-oxide particles, which refined the grain size from the edge as the oxidation penetrated.

Some Notes on the Properties of Chilled Metallic Shot and Grit Used in Sand-Blasting

By J. E. HURST (Past-President of the Institute of British Foundrymen) and J. H. D. BRADSHAW

(*Concluded from page 450.*)

Strength Properties

No really satisfactory method has been devised yet for the measurement of the strength properties on actual samples of shot or grit in the granular form, and it is difficult to conceive of a method for the direct determination of the simple strength properties on the material in this form. The strength properties that are likely to be of interest are the ultimate breaking strength either in tension, bending or compression, the resilience value, and perhaps the modulus of elasticity. The study of these properties in material for shot and grit will prove of value in the study of the resistance to disintegration of this material in service. It is of course less difficult to imagine some comparative method of measuring resistance to crushing or even to disintegration. For example, a predetermined quantity of shot or grit of known grade analysis might be blown in a form of shot-blast machine under standardised conditions and the differences in grade analysis after a treatment of this kind used as an index of the resistance to disintegration. Methods of this kind involve the standardisation of a number of arbitrary conditions, but of course they do not possess the advantage of affording a comparative measure of the very property in which both shot users and manufacturers are interested.

Work has been done in the authors' laboratories on the direct determination of the strength properties of chilled white irons using small annular ring formed specimens, permitting of the direct determination of the modulus of rupture, elasticity, permanent set, internal stress and resilience values. This has enabled some knowledge to be gained of the influence of the composition and thermal treatment on the strength properties of chilled white irons. The utilisation of data of this character involves an assumption that its comparative value holds for the same materials converted into much smaller masses such as particles of shot suitable for crushing into grit.

Knowledge of these various attributes of the mechanical strength properties in materials used for the manufacture of shot might prove of considerable value in dealing with some of the considerations which arise in service. For example, it is noticed that metallic grits vary in the tendency with which they lose their sharp edges by bending over and becoming rounded. This fact may be associated with the facility with which the material will undergo plastic deformation.

Specific Gravity

The determination of the specific gravity of metallic shot and grit may prove extremely useful. In the case of shot it may prove a useful guide as to the extent of unsoundness. In such round shot formed by the solidification of small molten drops of metal there is always a tendency for the formation of a shrinkage cavity near the centre of each shot. Typical examples of this sort of thing are shown in the illustrations Figs. 4 and 5, which reveal the cross-sections of a number of round shot ground and polished after embedding in white metal. The occurrence of this shrinkage cavity in small round shot of iron and steel was utilised by Ericson[5] in his studies of the volume changes of iron on solidification. Except in very small diameter shot there is always a tendency for the internal shrinkage cavity to be present, or alternatively a slight local depression of the surface probably due to the solidified crust not being strong enough to resist the suction effect involved in the progressive contraction on freezing. As a rule the cavity is regular and situated in the centre, but several cavities may sometimes appear in the same shot, and their shape may also be irregular and their position eccentric.

The solidity of round shot and the absence of cavity will be intimately connected with the

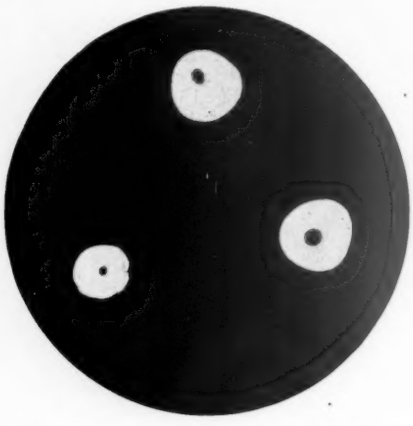

FIG. 4.—ROUND SHOT SHOWING CENTRAL SHRINKAGE CAVITY. × 4.

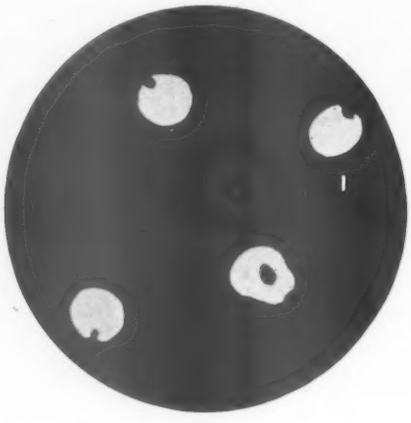

FIG. 5.—ROUND SHOT SHOWING ECCENTRIC SHRINKAGE CAVITY. × 4.

FIG. 6.—GRIT A. ETCHED IN PICRIC ACID. × 120.

FIG. 7.—GRIT B. ETCHED IN PICRIC ACID. × 120.

FIG. 8.—GRIT C. ETCHED IN PICRIC ACID. × 120.

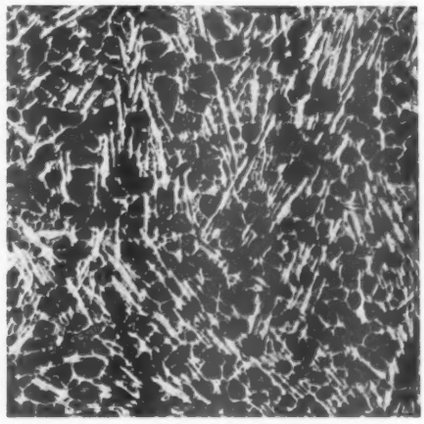

FIG. 9.—GRIT D. ETCHED IN PICRIC ACID. × 120.

[5] Carnegie Scholarship Memoirs, Vol. XXIII, 1934.

speed of freezing, and in the ordinary methods of shot production it is probable that the freezing speed is very much quicker than that used by Ericson. Accordingly shot of larger diameter is very frequently found to be quite sound. In the method used by Ericson shot having a diameter of below 0.6 mm. was generally found to be sound. Completely hollow shot are sometimes encountered, consisting of a thin shell only. In this case these are formed after the manner of bubbles, and are actually solidified metal bubbles. Occasionally where water has been used as a quenching medium, such hollow shot are found completely filled with water, an effect very much akin to the compound bubbles or drops which have been studied by various physicists, as for instance Boys.

In the case of crushed shot the specific gravity may be a rough and approximate guide to the strength and toughness of the material. Broadly speaking, the higher the specific gravity, the higher the strength properties. A higher specific gravity also indicates a proportionately higher energy content in moving particles of shot of identical size at the same velocity. The results of a number of determinations on samples of grit obtained from different sources are summarised in Table V. The variation from the lowest to the highest result is of the order of approximately 2 per cent. The determinations in each case were made by the ordinary density bottle method.

TABLE V.—*Specific-Gravity Determinations on Different Specimens of Chilled Metallic Shot and Grit.*

Specimen no.	Specific gravity.
1	7.50
2	7.53
3	7.50
4	7.40
5	7.48
6	7.44
7	7.53
8	7.42
9	7.52

Microstructure

The examination of the structural characteristics of shot and grit under the microscope presents a number of interesting features. The procedure followed in the preparation of specimens for micro-examination is similar to that for the hardness determination in which a number of grains are embedded in white metal and polished suitably for etching and examination. This procedure affords the opportunity of examining a number of grains picked at random from the same sample, thus providing a greater opportunity of detecting the presence of any variability in character of the material.

It is, of course, well known that in its preparation metallic shot and grit is chilled, and the knowledge of this, together with the details of the chemical composition, lead us to anticipate structures of the white iron type. A group of photographs of different makes of shot are included in Figs. 6 to 9. These show the etched structures etched with picric acid at a magnification of 120 diameters, and have been chosen to illustrate the wide differences in structure revealed by grit of different manufacture. At this magnification the specimens, Figs. 6 and 7, show a structure which appears to be a finely divided eutectic structure, specimen 7 showing, if anything, a little more of the darker etching solid solution background.

In Figs. 8 and 9 much more of the darker etching background appears and in Fig. 9 this background may be regarded as predominant. All the specimens show at least 1 per cent. of phosphorus, and the white etching constituent may be regarded as both the iron carbide and the phosphide eutectics. It is quite rational to suggest that a lower proportion of these constituents in the structure would be accompanied by increased strength and toughness characteristics, and it would not cause any surprise to know that the photograph, Fig. 9, is typical of the structure of the material which gave result No. 1 in Table I, the best result of these tests.

The structure of the solid solution ground mass, dark etching, generally requires a high magnification to resolve it, and the photographs, Figs. 10 to 13, are the corresponding photographs taken at a magnification of 1,200 diameters. All these show the ground mass to be martensitic in character, and in some the quenching has been so severe as to retain some austenite. The specimen, Fig. 2, showed portions of the ground mass structure which readily etched dark and was apparently unresolvable at 1,200 diameters, suggesting that the structure may be regarded as troostite and possibly indicating not nearly so effective chilling and quenching as has been received by the other specimens.

The martensitic character of the solid solution portion of the structure is probably the reason for the greater hardness of this material than that of ordinary white cast iron, which in the sand cast condition has the solid solution portion of the structure in the pearlitic condition. The general character of the structure shown in Figs. 9 and 13 is of special interest in view of

FIG. 10.—GRIT A. ETCHED IN PICRIC ACID. × 1,200.

FIG. 11.—GRIT B. ETCHED IN PICRIC ACID. × 1,200.

FIG. 12.—GRIT C. ETCHED IN PICRIC ACID. × 1,200.

TABLE VI.—*Allowable Limits for Sizing Abrasive Grain.*

Grit no.	Screen through which 100 per cent. must pass.	Control screen. No.	Control screen. Opening. Ins.	Maximum of oversize on control screen. Per cent.	Minimum retained. Per cent. on screen no.	Cumulative minimum retained. Per cent. on screen no.	Maximum of 3 per cent. through screen no.
10	7	8	0.0937	15	45 on 10	80 on 10 and 12 ..	14
12	8	10	0.0787	15	45 on 12	80 on 12 and 14 ..	16
14	10	12	0.0661	15	45 on 14	80 on 14 and 16 ..	18
16	12	14	0.0555	15	45 on 16	80 on 16 and 18 ..	20
20	14	16	0.0469	15	45 on 18	80 on 18 and 20 ..	25
24	16	20	0.0331	20	45 on 25	75 on 25 and 30 ..	35
30	18	25	0.0280	20	45 on 30	75 on 30 and 35 ..	40
36	20	30	0.0232	20	45 on 35	75 on 35 and 40 ..	45
46	30	40	0.0165	20	45 on 45	75 on 45 and 50 ..	60
54	35	45	0.0138	20	45 on 50	75 on 50 and 60 ..	70
60	40	50	0.0117	30	45 on 60	65 on 60 and 70 ..	80
70	50	60	0.0098	15	45 on 70	70 on 70 and 80 ..	100
80	60	70	0.0083	15	40 on 80	70 on 80 and 100 ..	120
90	70	80	0.0070	15	40 on 100	70 on 100 and 120 ..	140
100	80	100	0.0059	15	40 on 120	65 on 120 and 140 ..	200
120	100	120	0.0049	15	30 and 140 ..	60 on 140 and 170 ..	230
150	100	140	0.0041	15	40 on 170 and 200	75 on 170, 200 and 230	270
180	120	170	0.0035	15	40 on 200 and 230	65 on 200, 230 and 270	—
220	140	200	0.0029	15	40 on 230 and 270	60 on 230, 270 and 325	—

NOTE I.—These specifications shall not apply to abrasives used in the manufacture of abrasive paper and cloth products (coated abrasives).

NOTE II.—The screens referred to above are those of the United States Standard Sieve Series certified by the National Bureau of Standards.

NOTE III.—The allowable limits set forth in the above table are based on the shaking of a 100-gramme sample for 5 minutes on a "Rotap" machine operated at a speed of 290 revolutions per minute and 156 taps per minute. Where more than one screen is used they are to be agitated simultaneously.

the fact that this represents a sample which has given very good results in service. This consists of approximately half eutectic and half solid solution, this latter being predominantly martensitic. As already indicated, it is unreasonable to suppose that in material of this general composition, the adjustment of the actual composition, the quenching and thermal treatment conditions to yield a structure of this character would be accompanied by the highest degree of toughness and strength simultaneously with the highest degree of hardness. It is also clear that the micro-examination of chilled shot and grit may be usefully employed in the study of this class of material with the object of further improving its properties and characteristics.

Grading

The grading of both shot and grit has been referred to already as a factor of considerable importance in determining the performance of this material in any particular set of circumstances. In addition to the actual particle size, grading can be considered to include the particle shape, and it will be obvious that both particle size and particle shape will be governed largely by the methods used in manufacture. The requirements both as to shape and size vary to a

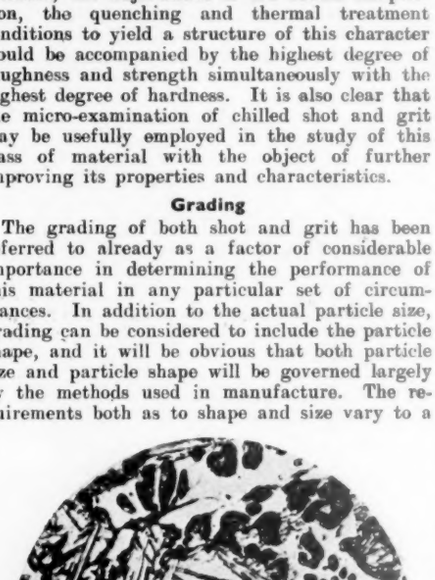

FIG. 13.—GRIT D. ETCHED IN PICRIC ACID. × 600.

large extent according to the purpose for which the material is to be used, and it cannot be too strongly emphasised that the selection of the most suitable quality from this point of view is largely in the hands of the user himself. The shot and grit manufacturer produces a range of sizes and characters, and in general places himself in a position to match the requirements of the user.

In the case of round shot, for example, the degree of approach of the particles to the truly spherical and also the uniformity of size is definitely more important in some applications than others. In the case of some of the stone-cutting and polishing operations, a greater degree of precision in these respects is required than in some of the applications of this class of material to rough cleaning operations in sand blasting. In the case of grit there are some operations, such as the cleaning of castings for enamelling purposes, where the maximum degree of angularity is required, and the presence of rounded surfaces is regarded as undesirable. On the other hand, there are users who prefer angular grit to show a certain extent of rounded surfaces.

It will be readily understood that owing to the wide variety of uses and requirements there are no hard and fast standards either as to size or shape. In general all manufacturers of shot and grit identify their grades by numbers, the lower numbers indicating the larger sizes and vice versa, to this extent following the system of numbering wire-mesh screens based upon the number of meshes per inch length. Even although there are no standards of grit size it is of some general interest to study a standard system of grading which has been drawn up in the U.S.A. for application to non-metallic abrasive grains. This system is evidently designed to exercise some degree of control over the extent of the spread of sizes which always occurs in the grading of material consisting of irregular shaped particles. (Table VI.)

For the majority of sizes control is exercised through five consecutive standard screens, and the spread of the sizes is over four screens. The majority of the material in a given size is that retained on two screen sizes, and this is at a maximum in the coarser grades at slightly over 80 per cent., a maximum limit being placed on the oversize and fines. It is of importance to note that the sieving conditions, using a "Rotap" machine, require to be standardised also. This standard system of grading does not apply to metallic abrasives—chilled shot and grit—and it is included in this Paper purely as an illustration of a system of grading as applied to non-metallic abrasives which in many respects are akin. The importance of this lies in the recognition of the spread in screen grading of material of this character made up of irregular sized and shaped particles.

With the increasing importance of both metallic shot and grit in foundry cleaning operations it becomes more and more desirable to study the character and properties of this material with the object of improving its efficiency in operation. Very little information on this subject has found its way in the technical Press, and it is hoped that this short study will correct this deficiency and serve as a kind of basis and also incentive for further work in the development of the properties of this material.

The authors wish to take this opportunity of thanking the Directors of Bradley & Foster, Limited, Darlaston, for permission to utilise the data presented in this Paper, most of which has been obtained in their research laboratories.

(*Continued from next column.*)

certainly never desirable. In this country at any rate an economic maximum would be little more than half the foot-speed per minute stated. The illustration of the troughing idler is of a very early type, in which the belt is simply turned up at the edges; this has long since been displaced by leading builders of conveyors, and, as is well known, the 5-roller troughed idler affords almost perfect troughing.

The author's choice of the foundry for the purpose of outlining a conveying system is a particularly happy one, for perhaps in no other section of manufacturing industry do we meet such extremes—there is the foundry in which no attempt has been made at mechanisation, and the foundry which is over-mechanised. One may wonder which is really the most efficient, on all counts.

The author has dealt very thoroughly with his subject, outlining a complete scheme of mechanisation, which, however, he does not carry a step beyond the rational and the economic, and he has therefore provided interesting and instructive reading for the foundry manager. Well written and profusely illustrated, the book is a sound contribution to engineering literature.

P. F. A.

The International Mercantile Diary and Year Book, 1938. Published by Syren & Shipping, Limited, 44 to 46, Leadenhall Street, London, E.C.3. Price 10s. 6d. post free.

It is assumed by foreigners that all United Kingdom firms know all about shipping and allied subjects. Our experience is that firms are either extremely well informed or abysmally ignorant on these matters. This year book makes an equally strong appeal to both. For the ignorant there is a wealth of information couched in simple language as to how to set about exporting goods, and overcoming worries if things go wrong. For the expert, the book brings to his notice the ever-changing conditions of business operations in overseas markets. It is extremely intelligently compiled and should find a place in every office where export business is conducted.

Book Reviews

Steels for the User. By R. T. Rolfe, F.I.C. Published by Chapman & Hall, Limited, 11, Henrietta Street, London, W.C.2. Price 21s. net.

This work, which consists of 275 pages of text divided into eleven chapters, deals solely with straight carbon steels. The various chapters discuss such important aspects as specified requirements for commercial steels (II); the effect of composition upon mechanical quality (III); bright and free-cutting steels (IV); industrial heat-treatment of low-carbon and high-carbon steels (VI-VII); case-hardening (VIII); use of steels at elevated temperatures (IX) and general principles of selection (XI).

The material included in these chapters has been carefully selected and generally well presented. It is evident that the author has had valuable practical experience, the results of which he has now put into print. Chapter IV is particularly useful, and the author is correct when he states that the subject of bright and free-cutting steels has received scant treatment at the hands of other authors. Amongst other valuable information is the continued comparison of actual results with standard specifications by public bodies such as the B.S.I., A.S.T.M., and Lloyd's.

The subject matter of Chapters I, V and X, dealing with the theoretical side, is not of the same high standard. One is surprised to see the iron-carbon diagram (after Sauveur) again reproduced. This form of the diagram has been shown now to be incorrect, and the continued use will only lead to confused ideas in the minds of those who have not received a metallurgical training. Similar criticism must be given regarding the statements on "α," "β" and "γ" iron (page 36). It is true that the statement on "β" iron is somewhat modified in the following paragraph.

The description of the structural changes in steels on heat-treatment is not at all satisfactory. On page 99 one reads that "Martensite . . . may conveniently be regarded as a solid solution of carbon in 'β' iron (or as is more generally believed in 'α' iron)"; on page 139 appears the statement "Martensite may be regarded as a supersaturated solid solution of carbon or Fe_3C in 'α' iron"; a further description of martensite based on lattice structure appears on pages 142 and 143.

Judgment on the book, considering for whom it is primarily written, is "good," and the valuable material contained in it, not forgetting the very useful specifications and data relating to actual results, more than counterbalances the few weak points.

L. S.-W.

Conveying Machinery. By WILLIAM H. ATHERTON, M.Sc. Published by The Technical Press, Limited, 5, Ave Maria Lane, Ludgate Hill, London, E.C.4. Price 21s. net.

This book is a comprehensive work in which the author has dealt exhaustively with a wide range of conveyors and elevators to meet all classes of industrial requirements. The work will be valuable alike to the engineer and the student; to the former the descriptions may perhaps appear somewhat laboured, but to the latter the wealth of detail will prove a fund of valuable information.

The chapter devoted to conveyor chains and wheels is singularly complete; it contains a lot of valuable data and offers in a concise form a ready means of comparison between the various types. A chapter of almost equal value is that devoted to the discharge of bucket elevators, because too often this important link in the chain does not always receive sufficiently close consideration by the works engineer.

Exception may be taken to a great deal that the author has said concerning the belt conveyor, particularly in the matter of speeds of belt. It is quite true that belts are run at the speeds laid down, but they are wholly exceptional; they are very rarely necessary, and

(*Continued in previous column.*)

A Discussion on Cupola Practice

EXPERIENCES IN A TEXTILE ENGINEERING WORKS

Many interesting phases of cupola control were touched upon during the discussion of MR. J. JACKSON'S Paper on "Cupola Practice in a Textile Engineering Works,"* including rammed linings, costing and sulphur reduction. As is usual at meetings of the Lancashire Branch of the Institute of British Foundrymen, the vote of thanks to the author was accorded immediately after the lecture. It was proposed by MR. H. V. GRUNDY, who said that Mr. Jackson had been very generous in the amount of information he had imparted. His figures in themselves provided a considerable amount of food for thought in regard to general cupola practice, and the remarks concerning return scrap were of very great interest.

The annealing of certain castings had been dealt with, and the question occurred to Mr. Grundy as to how the operation worked out in regard to cost, and whether it extended beyond the three types of castings mentioned in the Paper. He was thinking more particularly of requirements in regard to meter castings, because in electrical foundries it was endeavoured, as far as possible, to make the mixings soft enough in the first instance rather than to anneal them. The castings had to be machined at rapid rates, and possibly the disadvantages connected with the annealing operation would more than outweigh the advantages derived from it in regard to meter castings.

MR. J. HOGG seconded the vote of thanks. He thought it was unnecessary to say very much concerning the practical side of the Paper. He would merely state that the older members present had listened to it with great attention, while the information it contained must have been invaluable to the younger members of the Branch.

The vote of thanks was carried unanimously by acclamation.

Cost of Annealing Castings

MR. JACKSON remarked that Mr. Grundy had seemed puzzled as to why a number of castings should be annealed, instead of being made of a softer type of metal which would machine equally well, thus avoiding the cost of annealing. The point had been fully present in the minds of the foundry management, though there were special features in regard to the types of castings produced. He had mentioned the spindle whirl on a ring spinning and ring doubling frame, in regard to which it was necessary to have a smooth, close-grained casting which must not wear down rapidly. There were also the fine sections of separator bars and fine-pitch draft wheels, etc. It was essential that these be of a fine close-grained metal. With such metal without annealing the combined carbon was of such a nature that it would spoil even Widia tools. When he referred to a reasonably fast speed he really meant that the castings went through as fast as they could. The machines were running at a very fast speed indeed, and to anyone unfamiliar with the machines, it appeared extraordinary that men could maintain the feed. The possibilities of a number of softer metals had been explored, but they did not prove to be suitable. The cost of annealing was such a low charge that, on the whole, it was the better course to adopt. The foundry management, however, were always open to consider something new, and if anyone could show them a casting which would stand up to the work equally well, and save money by eliminating annealing, then that particular metal would be adopted immediately.

As a matter of fact, the question of different systems of annealing had been considered so seriously that at one time the views of the management were very much in the balance whether to retain the coke-fired system or to change over to gas. Very satisfactory annealing could be obtained by means of the gas oven, but it cost more than with coke-fired ovens. They had certain normalising and other work to do with the gas ovens which was of too fine a range for the coke ovens. It was not possible to retain such a fine point between the high and low range of temperatures with the coke ovens as was possible with the gas-fired ovens. Nevertheless, with the coke-fired ovens it was possible to achieve success for annealing castings, though it could not be done with steel, for which town's gas suggested itself as being suitable. Unfortunately, he had not the figures with him respecting cost of annealing castings, though he could produce them later if necessary.

Initial Pigging of Metal

MR. F. ANDREW observed that Mr. Jackson apparently ran down a quantity of metal initially and cast it either into the pig mould or into large unimportant castings. He assumed that this was because the metal was insufficiently hot. In his opinion, it was possible to get metal at a temperature of 1,300 deg. C. running very well. He asked what variation there was, say, with total carbon, silicon and manganese. He realised that the spout which was used would hold so much metal that it would tend to standardise the composition somewhat. What was the maximum sulphur permissible in the castings made?

He agreed with Mr. Jackson upon the value of the scrap, which was the cost of any alternative material required to replace it. With reference to the coke ratio, if only one cwt. was used to a ton, only an amount of air would be needed sufficient to burn that cwt.; but if 5 cwts. of coke per ton of metal were used, it would be necessary to burn 5 cwts. Thus, with regard to much-advertised statements as to the number of cub. ft. of air per ton, he thought it was not realised that a great deal depended upon the coke ratio.

Getting Initially Hot Metal

MR. JACKSON, replying to Mr. Andrews, said he appreciated the point that for a small foundry to throw away 5 or 6 cwts. into the pig bed was a serious matter, but not so for large-scale production. Raising the bed was one way of getting the metal hotter and reducing this loss. There was a fairly deep well in the furnace at the foundry with which he was associated, and the tuyeres were of fairly considerable height from the hearth. In consequence, the hearth would hold a large quantity of metal, advantage of which could be taken for rendering the mixings homogeneous. They had no receivers on their furnace; these unquestionably assisted in obtaining better mixing. The pig and scrap were loaded together in the charges. He had dispensed with the old system of first a layer of pig and then a layer of scrap, as with this system if they were running the metal off almost as fast as it melted they got a bogie load of all pig and a bogie load of all scrap. They tried to keep a fair amount of metal in the hearth in order to get a homogeneous mixing. It was a point worth considering that, if the tuyeres were lower, then, without raising the bed very high, hotter metal could be obtained very easily without having to discard much. He was inclined to think that from what he had heard of the practice in some foundries, where they claimed to get good hot iron at the very beginning of the blow, far too much coke was used on the bed, and instead of getting the metal down in 8 minutes it took 15 to 20 minutes. He thought by this practice it would cost more if they wanted to cast up all the metal without having any residue returned.

Sulphur Reduction by Soda Ash

At the foundry with which he was associated, although it was a fairly large place, there was no laboratory. If they were troubled with castings coming very hard, tests would certainly be made immediately. The management were strong advocates of the soda-ash treatment of metal; in fact, they were probably one of the first firms to adopt it in this country. During a strike period a few years back when most foundries were closed, Belgian and German coke was used and there was trouble from white iron due to excess sulphur. His firm started using soda ash, though not in the way it was usually advocated to treat it in the ladle. Their practice was to take an ordinary bucketful of soda ash, damp this, then work into a number of balls, say the size of cricket balls; these were then placed on the coke bed, before any iron was charged. That practice was still continued as the soundest and cleanest method of using soda ash. It was the most satisfactory method he had ever known for cleansing the metal of sulphur. It was the early metal which was most contaminated with sulphur, because it was the metal which had been stewing, as one might say, during loading up. When the first blow was put on there was more sulphur given up to the metal than at a later stage of the blow. He would prefer not to go into the question of the amount of air per ton, as it was a point concerning which he had not yet arrived at any definite opinion.

Maintaining Equilibrium by Rational Charging

MR. H. V. GRUNDY, referring to the charging of the cupola, observed that no information had been supplied concerning the steps taken to ensure that regular charging was carried on through the whole of the operations. When watching a cupola, it was invariably noticed that there was a slip immediately over the tapping spout. It was necessary to counteract this by dropping in some heavier metal there. It was also better to have the cupola charged right up to the charging door. There was to be seen, in some cupolas, a drop of perhaps 2 or 3 ft. below the charging door, which had the effect of decreasing the ratio between the diameter of the cupola and the height of the charge. There was a shorter time in contact with the heat, and consequently cooler melting than if the charge was maintained at the charging-door level.

How Control is Effected

MR. JACKSON said that the charges were kept level with the charging platform, which was 14 ft. from the hearth. The foundry foreman estimated how much he would need, and during the course of his visits would say: "Stop at this particular layer," or "Put in two more half-splits," or the like. The furnace man had been taught how to co-operate with the leading charger, and when the charge fell, at the blowing down period, then the baffle plate or damper from the Keith Blackman fan would be adjusted to give a meter register to a certain figure found by experience to be the best regulation of the amount of air required. Just before the finish it was shut off almost completely; if this were not done the metal would be blown up to the top of the spark chamber.

"Cool" Metal Production

MR. H. V. GRUNDY thought that Mr. Jackson had hardly dealt with the point raised. With some furnaces the men did not exercise care in charging the cupola. When throwing in the pig-iron, instead of spreading it equally over the area of the cupola, they dropped it more or less in one place. It was very often found that, for an area immediately above the tapping spout, there was a very light load. In consequence the air did not penetrate to the centre

* FOUNDRY TRADE JOURNAL, December 2, 1937, pp. 434-6.

of the cupola as it should, but crept up to the side, resulting in uneven melting.

Occasionally a foundry became temporarily short of metal on the cupola stage; perhaps it was not arriving as fast as it should do. The cupola was allowed to go down 2 ft. or 3 ft. or even more below the charging-door level, instead of being charged to 14 ft. from the bottom, and the cupola was only filled to 11 ft.; consequently there was not such a lengthy period for the stock to get down to the melting zone and the resulting metal was obviously cooler. It was one of the ways of getting a cool iron in the melting zone and at the spout.

MR. JACKSON said he was not aware that the firm with which he was associated made any special provision in that respect. They did, however, utilise the type of labour available, which was certainly very reliable. A certain method of making bad castings was to allow a cupola to work erratically, permitting the charges to get too low, and then rapidly charging up. The great point to be observed in all furnace work was regularity, and it was vital that it should be kept charged regularly. He had seen furnace practice where as much as 9 cwts. of pig-iron had been added, then a thick layer of coke, followed by 9 cwts. of scrap, or perhaps 12, then another layer of coke, and finally another layer of pig-iron. The pig-iron that was put on the second time would be a little different from that which was put on first. No one could possibly obtain a good metal in that way.

At one time, at the works of his firm, all charges were weighed, but this had proved to be too costly a process, so now everything was measured to the same degree of accuracy as it was previously. As a matter of fact, one foundry of the concern still continued to weigh their materials although others measured them.

Lining Preservation

MR. J. MASTERS remarked that Mr. Jackson referred to the metal blowing through before stopping up the taphole. This might be satisfactory for large foundries, but for the operation of a small cupola he never let the metal "blow through." He made a good bot-hole, and banked it up with black sand inside the cupola before lighting up; they could not afford to pig the metal. A good mixture of fairly dry black sand, with a little ordinary carbon blacking in it, was quite efficient. It easily pricked through, and it acted beneficially to the flow of metal down the cupola spout.

With regard to re-lining the furnace, Mr. Jackson's results certainly justified his attitude, yet if the bricks would slag at the temperature of initial firing of a cupola, it was obvious there must be some very poor brick. Thus, why slag it before putting on the ganister? This was putting on a very peculiar lining, because the lining would melt immediately round about the melting zone, especially when the temperature of cast iron was reached. It would go through the ganister to the slag on the brick; it was not insulating it. The first thing he would do, personally, was to see that the joints in the lining were as small as possible; and if he did require a facing of ganister he would put it on straightaway while the brickwork was clean. It would certainly be the means of getting a better frit. The reason for putting on ganister was to make a refractory face and also protect the brick. The first thing to do after lining up with a ganister covering was to wash with dilute silicate of soda, and a glaze would be immediately obtained with moderate firing. It was not advisable to fire heavily initially, while another factor was that the grout must be of a suitable nature. He had had good results by putting dry sea sand in between the bricks, and he had never experienced any trouble in running one bricked furnace during seven years. When this furnace was pulled down, the brickwork was still quite good.

MR. JACKSON said that the firm with which he was associated started ram-lining 15 years ago. He had never attempted to alter the practice with regard to bricks.

Carbon Pick-up

MR. A. PHILLIPS observed that Mr. Jackson had detailed a considerable amount of information concerning the melting of iron for the textile-engineeering industry. They must not, however, be led away with the idea that that was the only material which had to be melted in the cupola. If the method indicated by the lecturer were followed for melting cast iron required for textile castings there would probably be no difficulty, as a variation in the carbon content of 0.3 or 0.4 per cent. did not matter. In cast irons required for water-pressure work, in which it was necessary to control the carbon pick-up, the blast and coke must also be controlled, and probably Mr. Jackson would give some information about carbon pick-up.

Mr. Jackson had indicated an analysis of the coke, but this was not the end of everything in regard to coke itself. It might be possible to have a coke of exactly the same analysis, but if low-carbon irons were melted by it there would probably be a considerable carbon pick-up. In that case it was not the question of the carbon content of the coke but the physical properties of the coke.

Mr. Jackson had referred to the weather conditions on a good "fishing day," when hot metal could be obtained. The direction of the wind and the humidity of the atmosphere did seem to cause a slight difference in the melting of the metal, and thus there did appear to be something in it.

The lecturer was certainly a strong advocate of rammed lining, and much could be said in its favour. Was the long life of the rammed lining associated with the time when the soda ash (sodium carbonate) was used? The idea presented itself whether the sodium carbonate would attack bricks of a grog nature more than it attacked the special lining, which was of a different chemical composition from the bricks.

Mr. Jackson had estimated 4 per cent. loss in his melting practice, which seemed to be a very low figure. In several works the loss would probably be 6 per cent., and Mr. Jackson was to be congratulated.

The price of scrap was a hardy annual. Probably there would be, say, about 80 tons of scrap runners, and risers, and scrap castings lying about the yard of Mr. Jackson's foundry. He started with 80 tons at the beginning of November, and he would finish up with approximately the same quantity at the end of the month. He used so much bought scrap and pig-iron. That should be the material from which to calculate the material costs, and no doubt in many instances that was how the cost was worked out, otherwise the system would be very complicated.

Soda Ash and Rammed Linings

MR. JACKSON admitted that he had wondered himself whether soda ash was "kinder" to a monolithic lining than a brick lining; but soda ash was certainly not used until just after the War. Previously, the cupolas had been re-lined with brick every 18 months. He had heard it stated, on the other hand, that soda ash attacked a cupola very violently, breaking it down in columnar lumps. At the present time soda ash was only being used when the necessity occurred for its use, and he could not, personally, see that the cupola walls were being any more seriously damaged. It should be borne in mind, however, that their regular system of using it was to place it on the beds and not to put it on every charge throughout the blow. Nowadays there was not usually any excess of sulphur. A content of up to 0.1 per cent. sulphur was, however, not of any great difficulty in a foundry producing castings for textile purposes.

Economy in Alloying Elements

The absence of natural resources in Germany from which adequate supplies of the principal alloying elements for the manufacture of high-grade, special and high-speed steels could be drawn has led to intensified research in that country into practical measures for economising in some of these essential elements by replacing them partly or wholly with more readily available components. Among the recent Papers which have appeared on this subject is one by E. HOUDREMONT and H. SCHRADER in "Stahl und Eisen" reviewing recent research into the manufacture of high-speed steels in which the effects on cutting power and toughness of these steels of varying proportions of tungsten, molybdenum and vanadium has been studied.

In testing how far tungsten could be saved in the manufacture of standard tungsten high-speed steels, it was found that the tungsten content could be reduced with a corresponding increase in vanadium up to about 8 per cent. without affecting the cutting efficiency. By a partial substitution of tungsten by molybdenum, steel alloys are obtained whose cutting properties excel those of ordinary tungsten high-speed steels. Molybdenum-vanadium steels with excellent cutting properties were also obtained by a complete replacement of the tungsten and reduction of the alloying components beyond the usual limits.

Effect of Impulsive Shocks

The cutting efficiency of all molybdenum high-speed steels is reduced on exposure to impulsive shocks if a high cutting speed is used, but the reduction is small compared to that found with standard tungsten steel with 14 per cent. W and 2.5 per cent. V, which is used for general purposes and which was found less tough than high-tungsten steels. In forging and shaping molybdenum high-speed steels, there is marked tendency to surface decarburisation, which increases the tendency to crack during hardening. Molybdenum high-speed steel did not exhibit any adverse characteristics as regards scaling. The super-heating limit in hardening for substituted high-speed steels is not very much lower than that of ordinary tungsten steels with a low tungsten content, provided the temperature is not maintained for too long a period, as the former are extremely sensitive to protracted heating at a high temperature. Fusion spreads more rapidly in molybdenum high-speed steels if the hardening temperature is too high. Very long heating of tungsten high-speed steels results in a marked deterioration of the cutting efficiency, while in low-tungsten steels, and those containing no tungsten, the changes resulting on heating are small.

Federation of Iron and Steel Merchants

At a meeting in London on Friday, December 3, of representatives of the Iron Merchants' Association, the Steel Distributors' Association, the Steel Merchants' Association, the Light Rail and Arch Merchants' Association, the Tinplate Merchants' Association, and the Associated Group of Approved Billet Merchants it was decided to federate to a central organisation to be known as the Federation of Iron and Steel Merchants. It was intimated that other associations of merchants in the iron and steel trades would later become affiliated to the new organisation. Among the objects of the Federation is co-operation with the British Iron and Steel Federation and all associations and organisations of manufacturers engaged in the iron and steel industries. Mr. C. Bruce Gardner will be President of the new Federation.

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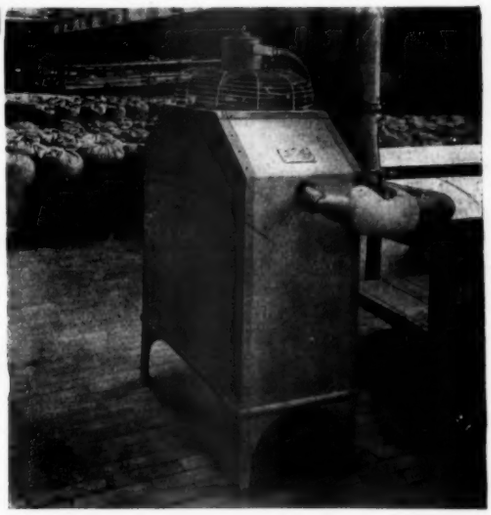

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The Week's News in Brief

Trade Talk

THE STAFF of Jackson, Elphick & Company, Limited, ironfounders, of Larkhall, held their annual dance recently.

THE RILEY STOKER COMPANY, LIMITED, have opened a new office at Emerson Chambers, Blackett Street, Newcastle-upon-Tyne.

NEARLY 200 PEOPLE attended the annual supper and dance of the staff of Harpers, Limited, engineers, of Craigshaw, in the Bon-Accord Hotel, Aberdeen.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, is issuing at par 97,135 £1 ordinary shares in the proportion of five for every eight held.

MR. A. B. WINDER, speaking at a function at the Vickers Works, Sheffield, of the English Steel Corporation, Limited, said that since 1932 they had doubled the number of men on their books, and their wage bill had been trebled.

OVER £1,000,000 IS to be spent by the L.M.S. Railway on the 1938 renewal programme. There will be 110 new locomotives, 324 new locomotive boilers, 732 coaching vehicles, 9,715 freight vehicles, and 375 road-rail containers. The normal renewal programme of new engines comprises 15 heavy freight, 20 mixed traffic, 30 goods, and 35 passenger tank engines.

THE ANNUAL STAFF DINNER of Stein & Atkinson, Limited, was held last Friday at Pagani's Restaurant, London. Mr. J. S. Atkinson presided, and was supported by Mr. S. E. Cash, Mr. T. C. Moorshead, Mr. C. H. Williams, and Mr. S. S. Kenyon (co-directors). Amongst those prominent in the foundry trade who accepted invitations were Mr. V. C. Faulkner, Capt. J. G. Bennett, Mr. A. L. Summers, Mr. W. S. Gifford, and Mr. D. A. Williams. An excellent cabaret, headed by Elsie Day and Rupert Hazel, was a feature of the evening's entertainment.

IN ORDER to have the opinion of the foundry equipment and supply houses as to a future exhibition policy, Mr. Kenneth Bridges, of F. W. Bridges & Sons, Limited, held a luncheon last Thursday at the Hotel Victoria, Northumberland Avenue, London. Very divergent views were expressed. Equipment houses in general thought biennial exhibitions too frequent. Some were in favour of reverting to a purely foundry exhibition, but a few disliked the situation of the Agricultural Hall as a centre. The supply houses were in many cases in favour of continuing at Olympia on account of the wider appeal of the Marine and Engineering Exhibition. Apparently there is no unanimity of opinion in this industry, and the difficulty of getting together a representative show still exists.

AT THE ANNUAL MEETING in London recently of the Industrial Welfare Society a message was sent to the King conveying the loyal greetings of the members and recalling His Majesty's interest in the work of the Society. The annual report commented on the long association of the King with the Society, and said that the King's interest had not diminished, for after his accession, although it was necessary for him to relinquish his position of President of the governing body of the Society, he immediately consented to become its first Patron. The report, dealing with the work of the year, stated that appointments of welfare workers and others made from the Society's panel were higher and offered sure evidence that there was an increasing need on the part of firms to centralise all their personnel questions in one department. The main difficulty to-day was to find an adequate number of candidates possessing the right kind of qualifications for this task.

COLONEL K. C. APPLEYARD, chairman of North Eastern Trading Estates, Limited, addressing the Economic Research Section of Manchester University on planning industrial development, said that the existing activities of the Government directly or indirectly affecting the location of industry were manifold. They comprised the placing of rearmament orders, shadow factories, and railway orders in Special Areas; directing and influencing the future of the iron and steel, coal, and other industries in co-operation with the accredited trade organisations; the provision of trading estates and site clearance schemes; and the remission of financial burdens under the Special Areas Amendment Act, 1937. To-day's free location of industry and limited Government activity had failed to end a situation for which it was originally responsible. Bolder and more rapid action was required. A reasoned plan, evolved by Government or by industry in concert with Government was needed. Inducements must be offered to occupy areas where industry was scarce or ill-balanced.

A CONFIDENT VIEW of the trade position was taken by Mr. Reginald McKenna, chairman of the Midland Bank, at the annual dinner in Birmingham of the Midland Area of the National Union of Manufacturers. Mr. McKenna said there was no evidence that we were on the downward curve of a trade cycle. There had been a certain decline in luxury trades, but returns he received from all parts of the country gave no indication that this decline was general, nor had we any reason to anticipate that it would be extended to industry as a whole. There had been an almost complete cessation of expenditure by large industrial concerns in the United States. Industrialists there felt they would be wise for the time being to refrain from using their liquid resources. That state of mind would not continue for ever. We should see American industrialists again active in the market. We might then look forward to a recovery in commodity prices. "Industry as a whole in this country shows no sign of a setback," he said. "Why should we anticipate for a moment the bogey of the trade cycle?"

Personal

MR. B. N. MOOKUJIE has resumed his seat on the board of the Indian Iron & Steel Company, Limited, in place of Mr. J. N. Mookujie, who has resigned.

MR. DAVID GIBB, chief sales manager of the Gothic Works, Falkirk, of R. & A. Main, Limited, has completed his 50th year of service with the firm.

DR. E. GREGORY has resigned from the post of Lecturer in Metallurgy at Sheffield University. Mr. Donald Havenhand, B.Sc., has been appointed Assistant Lecturer in Metallurgy.

MR. F. WILLIAMS, MR. T. K. SHAW and MR. E. MENSFORTH have been appointed local directors of Markham & Company, Limited, engineers, Broad Oaks Works, Chesterfield. Mr. Williams has been works manager at Broad Oaks for eight years, and Mr. Shaw, who has been at Broad Oaks almost 25 years, has been in charge of the estimating and sales department for the past eight years. Mr. Mensforth is a new-comer to the firm, until recently having been on the staff of the English Electric Company, Limited. Markham & Company, Limited, was recently acquired by John Brown & Company, Limited.

Obituary

MR. ROBERT KELLIE, chairman and managing director of Robert Kellie & Son, Limited, Dundee Foundry, Dundee, died on December 7.

THE DEATH has occurred in Arbroath of Mr. Alexander Coutts, a patternmaker by trade, who retired four years ago from the service of James Keith & Blackman Company, Limited, engineers, of Arbroath.

MR. FRANK BAXTER died on Wednesday, December 8, at his home at Chigwell, Essex, after several years' brave struggle against ill-health. Mr. Baxter, who was 52 years of age, was chairman of Baxter, Fell Company, Limited, iron and steel merchants, of Leadenhall Street, London. He was a member of the Committee of the London Iron and Steel Exchange and of the newly-formed Federation of Iron and Steel Merchants, and was prominent in many other associations connected with the iron and steel trades.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Regent Casting Company, Limited, 1A, Queen Street, Burslem, Stoke-on-Trent.—Capital £3,500. Ironfounders.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

473,613. JAKLIN, H. Beams or girders of T- or I-section.

473,696. PEARSON, J. L., and IMPERIAL CHEMICAL INDUSTRIES, LIMITED. Production of protective gases suitable for use in metal heat-treatment furnaces.

473,697. PEARSON, J. L., and IMPERIAL CHEMICAL INDUSTRIES, LIMITED. Production of non-oxidising gaseous mixtures.

473,726. FARRER, J. O. (Akt.-Ges. Oederlin & Cie). Process and apparatus for the production of metal castings.

473,748. NAAMLOOZE VENNOOTSCHAP WALLRAMIT HANDEL MAATSCHAPPIJ. Hard metal mandrels for drawing metal tubes.

473,800. WILLIAMS, W. P. (American Rolling Mill Company). Manufacture of helical lock seam pipe.

473,991. GRASSELLI CHEMICAL COMPANY. Cleaning and pickling of metals.

474,011. BUDERUS'SCHE EISENWERKE. Method of and apparatus for making centrifugally cast metal bodies.

474,060. DALRYMPLE, J. L. Machines for bending sheet metal.

474,199. KRUPP GRUSONWERK AKT.-GES., F. Cooling-bed for rolled material, particularly material in strip form.

474,224. BRASSERT, H. A., and BRASSERT & COMPANY, LIMITED, H. A. Basic Bessemer-steel processes.

474,245. REMY, VAN DER ZYPEN, & COMPANY. Device for metallising iron bands or wires.

474,275. COLD METAL PROCESS COMPANY. Reels for coiling hot-metal strip.

474,282. BRASSERT, H. A., and BRASSERT & COMPANY, LIMITED, H. A. Manufacture of steel.

474,321. BYRNE, E. L. W. (American Smelting & Refining Company). Cupel furnaces.

474,408. DUFFIELD, F. L. Production of iron from iron ore.

Company Reports

John Harper & Company, Limited.—Interim dividend of 3 per cent.

Greenwood & Batley, Limited.—Interim dividend on the ordinary shares of 3 per cent.

British Oxygen Company, Limited.—Half-yearly dividend on the 6½ per cent. cumulative preference shares.

Brush Electrical Engineering Company, Limited.—Deficit of £63,363 for the 18 months to June 30, 1937, making a total debit of £101,879 to be carried forward.

R. A. Lister & Company, Limited.—Profit for year to September 30, £199,170; brought in, £62,176; final ordinary dividend of 5 per cent. and a bonus of 6 per cent., making 16 per cent.; income-tax, £46,825; N.D.C., £4,750; to general reserve, £25,000; carried forward, £69,143.

Marshall, Sons & Company (Successors), Limited.—Profit for year ended September 30, £60,829; income tax, N.D.C. and investment reserve, £16,000; brought in, £13,275; interim dividend of 2½ per cent., £9,375; final dividend of 5 per cent, £18,750; to general reserve, £10,000; carried forward, £19,979.

Forthcoming Events

DECEMBER 21.

Institute of Welding:—"American Arc Welding Practice and Its Influence on Quality and Cost." Paper by Dr. J. H. Paterson, at Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, at 6.30 p.m.

The Institute of Vitreous Enamellers

DECEMBER 20.

Scottish Section:—Joint meeting with Falkirk Section of Institute of British Foundrymen: "Physical Properties of Enamels," Paper by Prof. Hay and colleagues, at Temperance Café, Lint Riggs, Falkirk, at 7.15 p.m.

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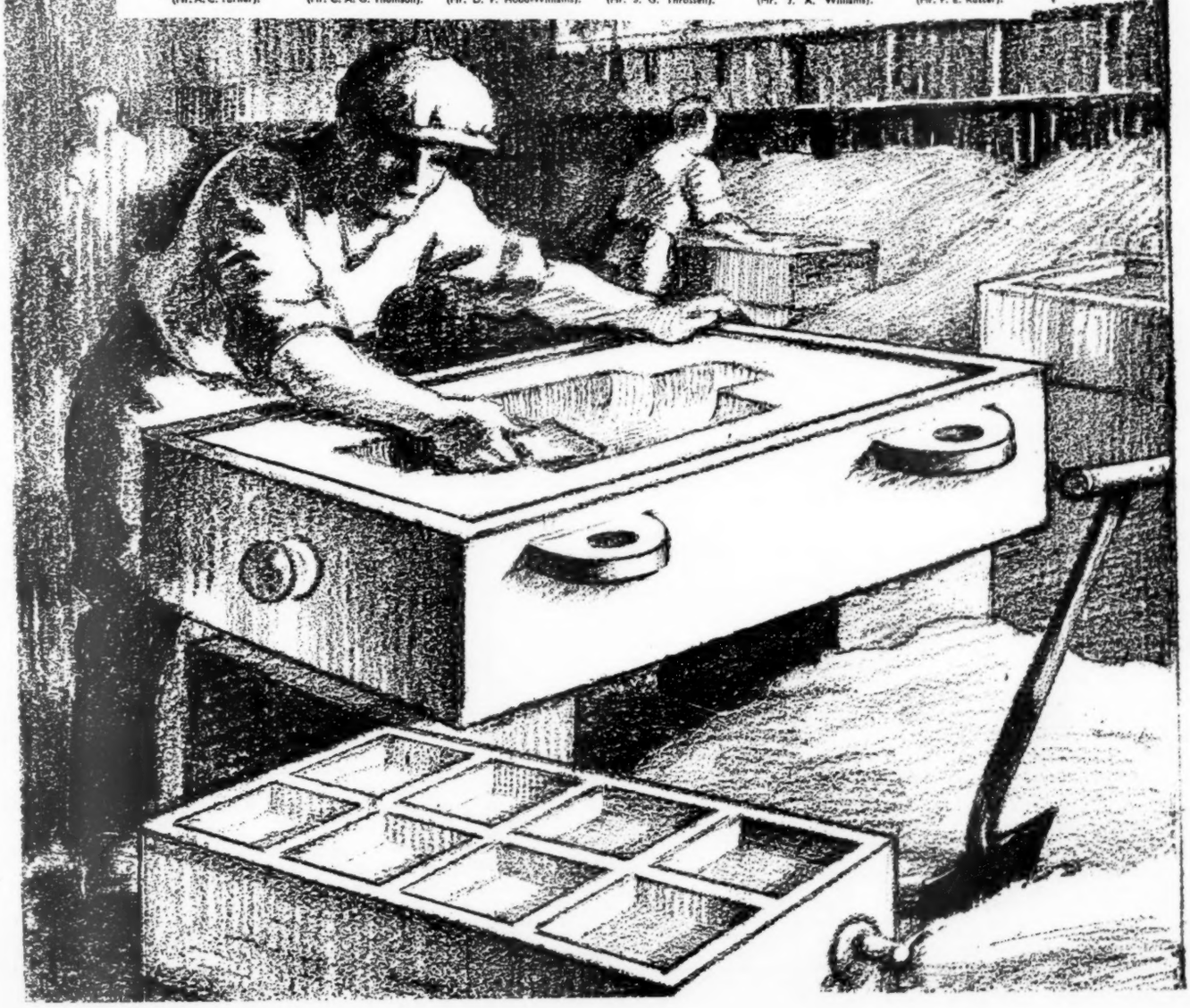
SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs, Exchange Place. Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).



Raw Material Markets

Iron and steel consumers continue to negotiate for supplies to be delivered over the first half of next year, and substantial tonnages are being booked. Previous commitments do not allow producers to accept all inquiries. There is little likelihood of any material expansion in the output of foundry iron as yet, but needs generally are being met without difficulty.

Pig-Iron

MIDDLESBROUGH.—A fair amount of business is being transacted for deliveries after the turn of the year, but, owing to the shortage of supplies, producers are having to exercise caution with regard to their commitments. It is hoped shortly to increase the output of Cleveland foundry iron, but there is no doubt that the demand will outstrip the supply for a long time to come. At the present time consumers are taking supplementary tonnages from Midland producers. For delivery in Middlesbrough and Falkirk over the first half of next year, No. 3 Cleveland G.M.B. is quoted at 109s., while Tyneside deliveries are 111s. and Glasgow 112s., less 5s. per ton rebate. The position with regard to hematite generally is satisfactory. Although consumers are not always able to contract for their full requirements, current deliveries are sufficient to allow them to maintain a good rate of operation at their plants. Business over the first six months of 1938 has been heavy. Makers are endeavouring to keep a firm grip on export inquiries and overseas consumers are receiving as much attention as possible.

LANCASHIRE.—The demand for all grades of pig-iron for delivery after the end of the year is strong and makers' order-books contain inquiries for quite large quantities of foundry, forge and hematite. In many cases the light-castings and jobbing foundries are not too active, while some of the textile-machinery concerns, also, are quieter, but other consuming establishments have heavy requirements. Scottish No. 3 iron remains in short supply in this area.

MIDLANDS.—Some of the producers in this area are in the position to despatch supplies to consumers in other districts, but this is not always the case, and some makers are still in arrears with deliveries. New business is not particularly heavy and light-castings and jobbing foundries are definitely quieter than they were a few months ago. For delivery to Birmingham and Black Country stations over the first half of the year, Derbyshire, Lincolnshire and North Staffordshire No. 3 are quoted at 111s., with Northamptonshire No. 3 at 108s. 6d., less 5s. per ton rebate. Although the motor-car industry is now less active, the demand for special-quality irons from other sources is maintained at a good level. Low-phosphorus iron is quoted at £6 7s. 6d. to £7 10s. The refined iron quotation has been advanced to £8 5s. per ton. This is now the minimum figure. East Coast hematite, No. 3, is quoted at £6 13s. 6d., with West Coast mixed numbers at 1s. per ton more. Prices will be 10s. per ton higher after December 31.

SCOTLAND.—Continental iron continues to be offered in this area, but consumers are not taking up further supplies, as they are participating in the recently-introduced loyalty rebate scheme. At the same time, home-produced iron is by no means plentiful. Scottish No. 3 foundry iron is quoted at 118s. at furnaces, with No. 1 at 120s. 6d. No. 3 Cleveland iron is quoted at 109s. f.o.t. Falkirk and 112s. f.o.t. Glasgow, less 5s. per ton rebate. In most cases steelworks are now better supplied with pig-iron.

Coke

The foundry-coke market remains firm, and there is a good demand for early deliveries. For delivery to Birmingham and district, best Durham coke is quoted at a minimum of 55s. 9d. per ton, while Welsh coke is offered at from 55s. to 65s., according to grade.

Steel

Holiday influences are beginning to affect the steel market, and the quieter tendency noticeable recently in new business has become more apparent, says the official report of the London Iron and Steel Exchange. The works, however, continue to make heavy deliveries, and consumers are taking up all the steel material available. There is also a considerable demand for small supplementary parcels needed for work in hand. The demand for semi-finished steel of all descriptions shows no signs of declining. The British works are operating at capacity, and in some cases have been unable to accept all the business offered. Even with the imports of Continental semis the consuming industries do not find it easy to maintain full production, although the position in this respect is much better than a few months ago. New business in finished steel materials remains quiet, but there is strong pressure from consumers to obtain deliveries, and the whole of the record output of the steelworks is passing immediately into use. Business with some of the export markets has improved of late, but, in general, the oversea demand is quiet.

Scrap

As reported in our last issue, a revised schedule of prices to operate from January 1 to June 30, 1938, has been agreed upon by the British Iron and Steel Federation and the National Federation of Scrap Iron and Steel Merchants. When railway rates were raised on October 1, scrap prices were increased generally by 6d. per ton; this has now been incorporated in the new price list. Further, the new prices are to be regarded as fixed rates, whereas previously the prices were the maxima which steelworks could pay. Otherwise, the changes which have been made are few. Prices have been increased slightly for some areas and decreased for others, in the light of the experience obtained with the scheme.

Metals

Markets have been easier again this week. In view of the approaching holiday and the annual stocktaking operations, however, this is not to be wondered at. Naturally, both producers and consumers of tin were disinclined to do much business pending the decision of the International Tin Committee with regard to quotas for the first quarter of the New Year. The quota has been cut by 40 per cent. to 70 per cent. of the standard tonnages.

Copper.—Business is quiet and consumers are unlikely to increase their stocks until after the turn of the year, when more settled conditions may prevail. Consumption remains satisfactory, and steady buying is likely to be entered into shortly, but it is difficult to envisage a period of really heavy purchasing while the outlook remains so uncertain. The United States market continues on the dull side, and prices have still to be stabilised.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £39 17s. 6d. to £39 18s. 9d.; Friday, £40 3s. 3d. to £40 5s.; Monday, £40 to £40 1s. 3d.; Tuesday, £39 2s. 6d. to £39 5s.; Wednesday, £39 10s. to £39 11s. 3d.

Three Months.—Thursday, £40 1s. 3d. to £40 3s. 9d.; Friday, £40 7s. 6d. to £40 8s. 9d.; Monday, £40 3s. 9d. to £40 6s. 3d. Tuesday, £39 7s. 6d. to £39 8s. 9d.; Wednesday, £39 13s. 9d. to £39 15s.

Tin.—As stated above the International Tin Committee has fixed the quota for the first three months of next year at 70 per cent. This decision was made after a protracted meeting on Friday. The official *communiqué* adds that the delegations of Bolivia, the Belgian Congo, and French Indo-China have agreed to surrender the arrears they are permitted to carry forward from 1937 under the agreement, plus certain additional tonnage up to an approximate total of 11,500 tons in all for 1938. The tonnages so surrendered will be divided between the Netherlands East Indies, Malaya, and Nigeria in proportion to their standard tonnages. This will enable the Netherlands East Indies, Malaya and Nigeria to export, in fact, at a rate of approximately 80 per cent. of their standard tonnages so long as the quota is at 70 per cent. The next meeting of the Committee will be held at The Hague on February 18.

The total cut in the output of tin is about 37,000 tons and it is estimated that the production over the first quarter of the year will be at a rate of slightly more than 160,000 tons yearly. Generally, the market is quite satisfied with the decision of the Committee. Strong criticism has been expressed in Malaya.

Official quotations were as follow :—

Cash.—Thursday, £193 to £193 5s.; Friday, £197 to £198; Monday, £199 to £199 5s.; Tuesday, £190 10s. to £190 15s.; Wednesday, £190 15s. to £191.

Three Months.—Thursday, £192 5s. to £192 10s.; Friday, £196 to £197; Monday, £198 5s. to £198 10s.; Tuesday, £189 10s. to £190; Wednesday, £190 to £190 10s

Spelter.—A report from Brussels states that it is understood that negotiations have been started with a view to reconstituting the International Zinc Cartel. It is expected, however, that they will be long and difficult, as certain producers oppose the restriction of production. As stated in our last issue, official confirmation of the negotiations is lacking, while the opposition may prove too strong for a revival of the Cartel. The market has been easier during the past week. The United States quotation has been reduced to 5 cents per lb.

Daily market prices :—

Ordinary.—Thursday, £14 17s. 6d.; Friday, £14 17s. 6d.; Monday, £15 1s. 3d.; Tuesday, £14 16s. 3d.; Wednesday, £14 17s. 6d.

Lead.—This market, also, has been less active, and little change can now be expected until after the end of the year.

Day-to-day quotations :—

Soft Foreign (*Prompt*).—Thursday, £15 15s.; Friday, £15 18s. 9d.; Monday, £16 5s.; Tuesday, £15 12s. 6d.; Wednesday, £15 13s. 9d.

Scrap.—More inquiries for delivery next year are coming to hand and business has improved somewhat. Apart from a small reduction in the price of lead, prices remain unchanged.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £40; foil, £94 to £98. Copper, £37 to £40; braziery, £35. Brass (clean), £23 to £25. Zinc, £9. Lead, £15. Gunmetal, £38 to £39.

Publication Received

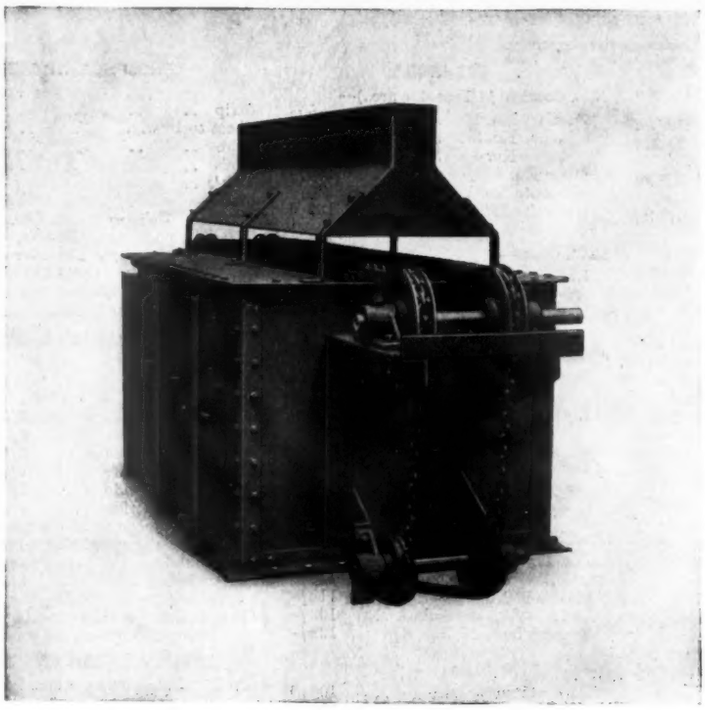
A Hundred Years in Steel—Firth-Brown Centenary, 1837-1937.

We are sure that the whole of the foundry industry will join us in congratulating John Brown & Company, Limited, of Sheffield, on the attainment of their centenary. It was a happy thought to utilise this occasion to publish a record of the firm's activities in book form. Those responsible for its production have indeed achieved praiseworthy results, as the binding, lay-out, illustration and type-setting are all excellent. Not only is the firm of John Brown dealt with, but also that of Thos. Firth & Sons. The story, though in general one of straight-line success, is interestingly told, but if it covered the "actors" rather than the "play" it would be truly fascinating, as even to-day, in those rather forbidding-looking hostelries of the east end of Sheffield, anecdotes are exchanged on side lights of the lives of these old ironmasters. John Brown's acquisition of a library; his commercial activities in Bilbao, and Mark Firth's participation in the celebration of the Sebastopol victory—recounted in this book—are typical yarns. Recipients of this decidedly pleasing and well-presented book can indeed count themselves fortunate.

Contracts Open

Southport, January 6.—292 yds. of wrought-iron railings and cast-iron standards, for the Town Council. The Borough Engineer, Town Hall, Southport. (Fee £1 1s., returnable.)

Huddersfield, December 21.—Cast-iron pipes from 2-in. to 12-in. internal dia.; also branches, bends, taper pipes, plug pipes, etc., for the Waterworks Department. The Waterworks Manager, 24, Ramsden Street, Huddersfield.



CONTINUOUS CHAIN FURNACE

FOR LOCAL HEATING, HEATING FOR JOGGLING FISHPLATES, etc., etc.

Illustration shows oil-fired furnace, but any type can be arranged to suit requirements.

FURNACES, STOVES, SAND PLANTS

SPECIALISTS

COGGON FOUNDRY EQUIPMENT LTD Ovenden HALIFAX

Phone: 2423 Halifax Grams: COGGON, HALIFAX

Green's "Emergency" Cupolette is a great Money Saver.

Sizes from 5 to 40 cwts. capacity per hour.

Green's STEEL CONVERTER PLANTS are Second to None

COMPLETE FOUNDRY MELTING EQUIPMENTS FOR DEALING WITH CAST IRON, STEEL & BRASS are OUR SPECIALITY

Green's Rapid "Economic" Cupola

Sizes: 1 to 20 tons per hour capacity.

CUPOLA CHARGING MACHINES. LADLES. RATTLERS. MOULDING MACHINES. SAND MILLS AND SIFTERS. ROTARY CORE-MAKING MACHINES. CORE STOVES, PIG-IRON BREAKING MACHINES, Etc. Etc.

Brass Melting Furnaces
All sizes and types, Coke and Oil Fuel.

GEORGE GREEN & CO.,
Foundry Equipment Engineers and Contractors,
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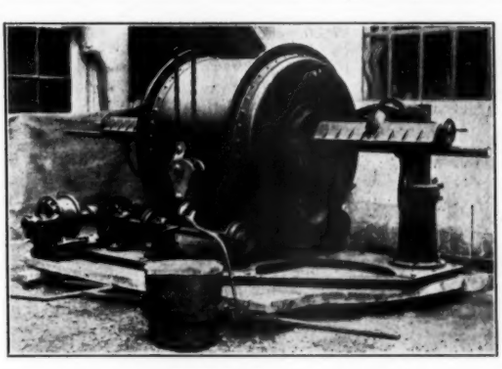

METALECTRIC ROTARY ROCKING ARC FURNACE
FOR
MELTING CAST IRON & ALLOYS
NON FERROUS ALLOYS

SIMPLICITY OF CONSTRUCTION
ABSOLUTE SECURITY & RAPIDITY OF ACTION
LOW MAINTENANCE COST

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CORNWALL RD. SMETHWICK BIRMINGHAM TEL. SMETHWICK 1561 & 2
LONDON OFFICE . . . 16 GROSVENOR PLACE, S.W.1
COLOGNE. PARIS. MILAN.

RAW MATERIALS—PRICE LIST

(Wednesday, December 15, 1937)

COPPER

	£	s.	d.
Standard cash	39	10	0
Three months	39	13	9
Electrolytic	43	5	0
Tough	42	10	0
Best selected	43	0	0
Sheets	76	0	0
India	53	10	0
Wire bars	44	5	0
Ingot bars	44	5	0
H.C. Wire rods	47	15	0
Off. av. cash, Nov.	39	7	4 7/11
Do., 3 mths., Nov.	39	13	0 5/22
Do., Sttlmnt., Nov.	39	7	7 4/11
Do., Electro, Nov.	44	18	7 7/11
Do., B.S., Nov.	44	19	8 8/11
Do., Wire bars, Nov.	45	16	9 9/11
Solid drawn tubes			12¼d.
Brazed tubes			12¾d.
Wire			8¼d.

BRASS

Solid drawn tubes	11¼d.
Brazed tubes	13½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	6¼d.
Sheets to 10 w.g.	8¾d.
Wire	8¾d.
Rolled metal	8½d.
Yellow metal rods	6¾d.

TIN

	£	s.	d.
Standard cash	190	15	0
Three months	190	0	0
English	190	15	0
Bars	192	10	0
Straits	194	10	0
Eastern	194	12	6
Banca (nom.)			—
Off. av. cash, Nov.	190	13	7 7/11
Do., 3 mths., Nov.	190	5	1 4/11
Do., Sttlmt., Nov.	190	14	3 9/11

SPELTER

	£	s.	d.
Ordinary	14	17	6
Remelted	11	15	0
Hard	11	10	0
Electro, 99.9	18	12	6
English	16	0	0
India	14	10	0
Zinc dust	23	15	0
Zinc ashes	6	0	0
Off. aver., Nov.	15	17	9 9/22
Aver., spot, Nov.	15	16	1 23/44

LEAD

	£	s.	d.
Soft foreign, ppt.	15	13	9
Empire (nom.)	16	8	9
English	17	15	0
Off. aver., Nov.	16	14	2 5/11
Aver. spot, Nov.	16	14	1 19/44

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	29	0	0 to	29	10	0
Do., V.M. ex-whse.	29	0	0 to	29	10	0
Rods				23	0	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	81	0	0 to	82	0	0
Chinese, ex-whse. (nom.)				66	0	0
Crude, c.i.f.				39	0	0

QUICKSILVER

	£	s.	d.
Quicksilver	13	0	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£14 10 0
45/50%	£12 0 0
75%	£17 0 0
Ferro-vanadium	
35/50%	12/8lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	9/3 lb.
Tungsten metal powder—	
98/99%	9/6 lb.
Ferro-chrome—	
2/4% car.	£34 15 0
4/6% car.	£24 5 0
6/8% car.	£24 0 0
8/10% car.	£24 0 0
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 5 0
Max. 0.5% car.	£41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	9 to	3	11	3
Mixed iron and steel	3	6	3 to	3	8	9
Heavy cast iron	3	8	9 to	3	11	3
Good machinery				3	17	6
Cleveland—						
Heavy steel, best	3	7	0 to	3	9	6
Steel turnings	2	13	0 to	2	15	6
Heavy cast iron				4	5	0
Heavy machinery				4	10	0
Midlands—						
Short heavy steel				4	0	0
Light cast-iron scrap	3	0	0 to	3	2	6
Heavy wrought iron	4	0	0 to	4	5	0
Steel turnings	2	5	6 to	2	8	0
Scotland—						
Heavy steel, best	3	5	0 to	3	7	6
Ordinary cast iron	4	7	6 to	4	10	0
Cast-iron borings	2	0	0 to	2	2	6
Wrot-iron piling				4	15	0
Heavy machinery	4	15	0 to	4	17	6

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	32	0	0
Brass	23	10	0
Lead (less usual draft)	14	0	0
Tea lead	11	10	0
Zinc	9	0	0
New aluminium cuttings	71	0	0
Braziery copper	29	0	0
Gunmetal	32	0	0
Hollow pewter	135	0	0
Shaped black pewter	97	0	0

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	108/6
,, No. 3	106/-
,, No. 4	105/-
Forge No. 4	105/-
Hematite No. 1	123/-
Hematite M/Nos.	122/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-
,, d/d Birm.	134/6
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	108/-
,, No. 3 fdry.	111/-
Northants forge	105/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	108/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	123/-
Sheffield (d/d district)—	
Derby forge	105/6
,, fdry. No. 3	108/6
Lincs forge	105/6
,, fdry. No. 3	108/6
W.C. hematite	128/6
Lancashire (d/d eq. Man.)—	
Derby fdry, No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Summerlee, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0 to	13	15	0
Nut and bolt iron	11	12	6 to	12	2	6
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up
Steel—						
Plates, ship, etc.	11	8	0 to	11	10	6
Boiler plts.	11	18	0 to	12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5¼ in.				12	0	6
Rounds under 3 in. to ⅜ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	11½d.
Wire	12⅞d.
Rods	13½d.
Tubes	18⅜d.
Castings	15½d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2⅝ to 1/8⅝
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	38/6
,, furnace	37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	22/6
,,	28×20	,,	45/-
,,	20×10	,,	35/-
,,	18¾×14	,,	25/-
C.W.	20×14	,,	19/6
,,	28×20	,,	39/-
,,	20×10	,,	30/6
,,	18¾×14	,,	21/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£12	0	0 to	£13	0	0
Bars-hammered, basis	£20	0	0 to	£22	0	0
Bars and nail-rods, rolled, basis	£19	0	0 to	£20	0	0
Blooms	£18	0	0 to	£19	0	0
Keg steel	£30	0	0 to	£35	0	0
Faggot steel	£20	0	0 to	£25	0	0
Bars and rods dead soft st'l	£19	0	0 to	£20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.	
Dec. 9		39	17	6	dec. 7/6
,, 10		40	3	9	inc. 6/3
,, 13		40	0	0	dec. 3/9
,, 14		39	2	6	,, 17/6
,, 15		39	10	0	inc. 7/6

Electrolytic Copper

		£	s.	d.	
Dec. 9		43	10	0	dec. 20/-
,, 10		44	0	0	inc. 10/-
,, 13		44	0	0	No change
,, 14		43	5	0	dec. 15/-
,, 15		43	5	0	No change

Standard Tin (cash)

		£	s.	d.		
Dec. 9		193	0	0	dec.	35/-
,, 10		197	0	0	inc.	80/-
,, 13		199	0	0	,,	40/-
,, 14		190	10	0	dec.	170/-
,, 15		190	15	0	inc.	5/-

Tin (English ingots)

		£	s.	d.		
Dec. 9		193	0	0	dec.	35/-
,, 10		197	0	0	inc.	80/-
,, 13		199	0	0	,,	40/-
,, 14		190	10	0	dec.	170/-
,, 15		190	15	0	inc.	5/-

Spelter (ordinary)

		£	s.	d.		
Dec. 9		14	17	6	dec.	12/6
,, 10		14	17	6	No	change
,, 13		15	1	3	inc.	3/9
,, 14		14	16	3	dec.	5/-
,, 15		14	17	6	inc.	1/3

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Dec. 9		18	12	6	dec.	13/9
,, 10		18	13	9	inc.	1/3
,, 13		18	17	6	,,	3/9
,, 14		18	11	3	dec.	6/3
,, 15		18	12	6	inc.	1/3

Lead (soft foreign, prompt)

		£	s.	d.		
Dec. 9		15	15	0	dec.	7/6
,, 10		15	18	9	inc.	3/9
,, 13		16	5	0	,,	6/3
,, 14		15	12	6	dec.	12/6
,, 15		15	13	9	inc.	1/3

Lead (English)

		£	s.	d.		
Dec. 9		17	15	0	dec.	10/-
,, 10		18	0	0	inc.	5/-
,, 13		18	5	0	,,	5/-
,, 14		17	15	0	dec.	10/-
,, 15		17	15	0	No	change

Imports and Exports of Pig-iron, Castings, etc., in November and the Eleven Months 1937, compared with November and the Eleven Months 1936

	November.		Eleven months.		November.		Eleven months.	
	1936.	1937.	1936.	1937.	1936.	1937.	1936.	1937.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	17,832	19,074	123,808	190,664	58,217	103,872	394,466	814,417
,, ,, Other British Countries	—	—	—	42,609	1	—	1	234,166
,, ,, Foreign Countries	11,136	55,088	101,166	341,819	40,922	333,968	351,219	2,110,829
Total	28,968	74,162	224,974	575,092	99,140	437,840	745,686	3,159,412
Castings and forgings	246	598	6,027	3,227	7,846	18,075	209,125	100,263
Cast pipes and fittings	199	261	1,491	1,934	7,184	7,024	49,711	48,058
Stoves, grates, etc.	114	61	766	853	8,358	6,931	68,450	81,059
Baths	771	337	7,556	7,922	17,564	9,296	182,466	196,774
Hollow-ware, all kinds	546	317	3,564	3,695	20,232	24,289	182,402	227,696
Exports.								
Pig-iron, forge and foundry	4,693	6,253	52,052	83,464	17,877	41,013	200,901	455,300
,, acid	1,836	6,753	37,651	60,716	7,194	45,058	138,553	347,534
,, basic	271	5	423	573	798	43	1,608	3,570
Total	6.800	13,011	90,126	144,753	25,869	86,114	341,062	806,404
Castings and forgings	385	117	3,708	2,674	13,824	5,681	138,983	103,802
Cast pipes and fittings, up to 6 in. diameter	5,419	5,211	52,847	55,785	57,694	63,127	590,410	635,883
,, ,, ,, over 6 in. ,,	3,599	2,279	36,000	44,336	29,874	25,499	295,318	366,293
Stoves, grates, etc.	976	774	9,665	9,993	48,471	44,414	486,244	536,981
Sanitary cisterns	238	303	2,753	3,307	7,786	11,584	85,377	113,077
Bedsteads, including tubes therefor	428	382	4,564	5,292	15,147	17,437	167,044	211,819
Hollow-ware	530	381	5,117	4,791	18,261	15,292	183,704	174,161

WILLIAM JACKS & COMPANY,
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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

MOULDER, apprentice trained, desires progressive position. Good iron, steel and aluminium experience. Green, dry and oil sand, etc. Machine, floor. Technical trained; held positions as head moulder and chargehand.—Box 714, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

KAYE & CO. (HUDDERSFIELD), LTD., wish to thank all applicants for the position advertised on December 2, which has now been filled.

ALUMINIUM Moulder with good experience wanted to take charge as a Working Foreman in a foundry at Reading. Excellent prospects for right man.—Write to: Box 706, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOREMAN Coremaker wanted, used to quick production of good quality small and medium cores. Permanent post and good wage plus bonus. Reply giving age, experience, and wage expected to: Box 704, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

IRON Moulders and Coremakers required for foundry in Manchester area, used to castings between 10 cwts. and 30 tons. Regular and permanent employment offered to suitable men. —Apply Box 708, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

VITREOUS ENAMELLING.—Required for West of England, a thoroughly competent man to take charge of department covering sheet and cast-iron enamelling (wet process). Frit making not essential. Give full particulars of experience, copies of testimonials, etc., stating when available to take up duties to: Box 712, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, ; Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOUNDRY Foreman with thoroughly practical training and experience requires re-engagement. Experience includes general engineering castings up to 20 tons, also repetition work, machine and plate (315)

FOUNDRY or Works Manager. Position required by young man with considerable experience as Manager and Superintendent, including non-ferrous work. Modern production and costing methods. (316)

PROPERTY

MODERN Steelfoundry at Rotherham, main building 65 ft. by 150 ft. (erected 1916); complete with 10-ton crane. Site 1 acre. Siding on L.N.E. Rly. Adjacent canal.—Apply: GORDON, P.O. Box 98, Sheffield.

MACHINERY

FOR SALE.—Three Cupolas for Cast Iron, drop bottom type, complete with lining, inside diameters, 6 ft., 5 ft. and 3 ft. 9 in. respectively.

One Physic Cupola, 3 ft. 4 in. dia.

Three Gas-fired Bogie Annealing Furnaces (Wincott), 15 ft. by 10 ft. by 6 ft. 3 in.; one as new.

One M.S. Self-supporting Chimney, 70 ft. high by 2 ft. 9 in. inside dia.

Box 702, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MOULDING Machines for Sale. Bonvillain & Ronceray. Four No. 3A; two No. 5A. Also Ketin & Thiriart Motor-driven Sand Preparing Plant. May be inspected at any time.—STREET, c/o AUSTIN MOTOR CO., LTD., Longbridge Works, Northfield, Birmingham.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

SAND MIXERS AND AERATORS.—**The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.**

ELECTRIC CUPOLA BLOWERS (large stock), including two 50-h.p. 3/50/400 volts, 2,900 r.p.m.; Keith Blackman; 12-in outlet.

30-h.p. ditto; 12-in. outlet.

5-h.p. ditto; 6-in. outlet.

20-h.p. 460 volts d.c., 2,400/1,900 r.p.m.; 10-in. outlet.

EXHAUST FANS (large stock), electrical and belt driven.

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One 4½-ton 460 volts d.c., Vaughan.

Two 2-ton ditto, Morris.

One ½-ton 220 volts d.c., Morris (as new).

One ½-ton 3/50/440 volts, Aabacas.

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AIR COMPRESSORS: 30 in stock in sizes 500 to 20 cub. ft.

ELECTRIC MOTORS: Large stock to suit almost all electric systems.

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15-ton GEARED FOUNDRY CRANE LADLE; excellent condition; cheap.

Four 5-cwt. Pressed Steel FOUNDRY LADLES; 17" dia. x 16" deep.

Three 5-cwt. Pressed Steel FOUNDRY LADLES.

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'Grams: "Forward." 'Phone: 23001 (10 lines).

ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

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PATTERNS IN WOOD AND METAL for all branches of Engineering. Moulding methods carefully considered.—FURNESTON & LAWLOR, Letchworth.

MISCELLANEOUS—*Continued*

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NEWS FOR BRASSFOUNDERS.—"Quick-Set" Furnace Cement, triple life and for repair. "Clean-RUN" Topping Flux, gives extra life for crucibles and saves fuel. Particulars from: WILLIAM OLSEN, LTD., Hull.

LARGE selection of good Cast-iron and Steel Moulding Boxes (interchangeable), small sizes. Cheap for immediate disposal.—Box 710, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FINEST FOUNDRY BLACKINGS AND FACINGS. Pure Ceylon Plumbago (Import direct), Finest Core Gum, White Dust, Parting Powder (Silica free), Pure Ground Carbon and Electrodes. Quality at reasonable prices. Orders repeated. Send for free sample.

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One Sand Grab and two Sand Valves complete with hoppers for placing above moulding machines. Cheap

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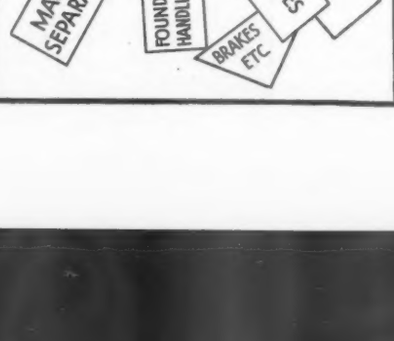
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